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Vol. II  
HDM

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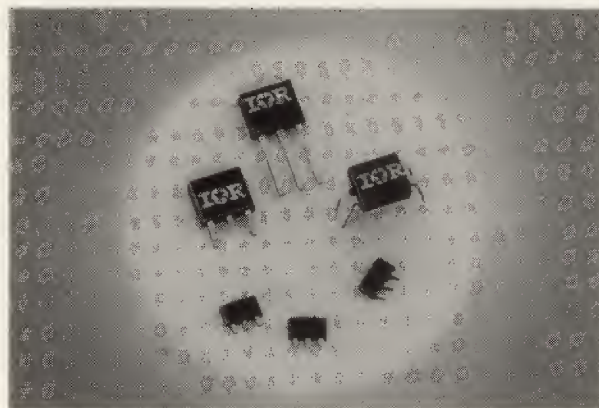
# HEXFET

## Power MOSFET

### Designer's Manual

DIPs  
D-Paks  
I-Paks  
SOT-89s

International  
**IOR** Rectifier



## About Volume II

This Designer's Manual is specifically dedicated to International Rectifier's commercial line of HEXFET surface mount (D-Pak, I-Pak, SOT-89) and DIP devices. These power MOSFETs are recognized throughout the world as the industry standard for ruggedness, low  $R_{DS(on)}$ , and consistency of mechanical and electrical specifications. To locate the device to fill your specific design needs, see the Table of Contents and/or Selector Guide section.

## DATA SHEETS

The technical data sheets contained in this Volume II cover all product upgrades, as well as our new HEXFET III generation of power MOSFETs. You are invited to contact your local IR field representative or our home office for additional product data or applications assistance.

## OTHER PUBLICATIONS

International Rectifier also has Designer's Manuals covering TO-220, TO-3P, FullPaks, and other HEXFET devices, as well as separate manuals for government and space products, and applications and reliability data. These and other technical publications featuring IGBTs, power ICs, etc., are listed in the Available Literature section of this Designer's Manual. For ordering information, see page 156.

*HEXFET is a trademark of International Rectifier*

International  
**IOR** Rectifier

# HEXFET<sup>®</sup>

## DESIGNER'S MANUAL



PUBLISHED BY  
INTERNATIONAL RECTIFIER, 233 KANSAS ST., EL SEGUNDO, CALIFORNIA 90245



# **HEXFET<sup>®</sup>**

## **DESIGNER'S MANUAL**

### **Volume II**

**POWER MOSFETs**  
**DIP, D-PAK, I-PAK, and SOT-89**

**HDM-1**  
**First Printing**

**PUBLISHED BY**  
**INTERNATIONAL RECTIFIER, 233 KANSAS ST., EL SEGUNDO, CALIFORNIA 90245**

# **HEXFET Power MOSFETs**

## **An Introduction to HEXFET Power MOSFETs**

### **Foreword**

Since the introduction of the HEXFET power MOSFET in 1979, International Rectifier has become the acknowledged technology and market leader in power MOSFETs worldwide. HEXFETs set the standard for the industry in device characteristics and ratings, product quality and reliability, and breadth of line.

HEXFET III devices, specially designed for high-volume low-cost manufacture at HEXFET America, are recognized as the most rugged standard-product power MOSFETs in the industry. Introduced in late 1986, HEXFET III devices are so rugged that designers can eliminate external protection circuitry and more readily use HEXFETs in such applications as motor control and power supplies. International Rectifier provides three key ruggedness ratings on HEXFET III devices:

Single-shot avalanche energy to accommodate occasional high-energy over-voltage transients.

Repetitive avalanche energy to eliminate external protection circuitry.

Dynamic  $dv/dt$  capability to withstand harsh conditions in motor control and similar applications without externally-connected diodes.

HEXFET III cell density has been optimized for each voltage range to provide lower on-resistance per unit area. HEXFET power MOSFETs remain the first choice for the full range of commercial, industrial, and aerospace/defense power supply and motor control applications.

Producing HEXFET III power MOSFETs at HEXFET America, International Rectifier integrates design, process, and manufacturing to provide the world's most reliable power MOSFET at the lowest cost-per-amp.

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# HEXFET Power MOSFETs

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## Table of Contents


<b>HEXFET Power MOSFETs</b>	<b>Page</b>
Alpha-Numeric Index .....	iv
Product Selection Guide .....	v
 <b>Package Styles, Channel</b>	
DIP, N-Channel .....	1
DIP, P-Channel .....	39
D-Pak and I-Pak, N-Channel .....	63
D-Pak and I-Pak, P-Channel .....	105
SOT-89 .....	131
 <b>Logic Level Devices</b>	
DIPs .....	133
D-Paks and I-Paks .....	141
 <b>Appendices</b>	
Appendix A: Peak Diode Recovery $dv/dt$ Test Circuit .....	149
Appendix B: Package Outline Mechanical Drawings .....	151
Appendix C: Tape and Reel Information .....	153
Appendix D: Part Marking Information .....	155
Appendix E: Other Available Literature .....	156
 <b>Other Surface Mount Products</b> .....	157
 <b>Worldwide Operations</b> .....	Back Cover

## Alpha-Numeric Index


Part Number	Page	Part Number	Page
IRFD014.....	1	IRFR224/U224.....	97
IRFD024.....	7	IRFR310/U310.....	99
IRFD110.....	13	IRFR320/U320.....	101
IRFD120.....	19	IRFR420/U420.....	103
IRFD1Z0.....	25	IRFR9014/U9014.....	105
IRFD210.....	31	IRFR9024/U9024.....	111
IRFD220.....	37	IRFR9110/U9110.....	117
IRFD9014.....	39	IRFR9120/U9120.....	119
IRFD9024.....	41	IRFR9210/U9210.....	125
IRFD9110.....	47	IRFR9220/U9220.....	127
IRFD9120.....	53	IRFRC20/UC20.....	129
IRFD9210.....	59	IRFS1Z0.....	131
IRFD9220.....	61	IRLD014.....	133
IRFR014/U014.....	63	IRLD024.....	135
IRFR024/U024.....	69	IRLD110.....	137
IRFR110/U110.....	75	IRLD120.....	139
IRFR120/U120.....	81	IRLR014/U014.....	141
IRFR210/U210.....	87	IRLR024/U024.....	143
IRFR214/U214.....	89	IRLR110/U110.....	145
IRFR220/U220.....	95	IRLR120/U120.....	147

# Selection Guide


## Logic Level D-Pak (5 volt gate)

Part Number	$BV_{DSS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRLR014 IRLR024	60	0.20 0.10	8.5 16	31 64	141 143	 D-Pak TO-252AA
IRLR110 IRLR120	100	0.54 0.27	4.6 8.4	18 31	145 147	

## Logic Level DIP (5 volt gate)

Part Number	$BV_{DSS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRLD014 IRLD024	60	0.20 0.10	1.7 2.5	14 20	133 135	 HD-1
IRLD110 IRLD120	100	0.54 0.27	1.0 1.3	8.0 10	137 139	


## Logic Level I-Pak (5 volt gate)

Part Number	$BV_{DSS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRLU014 IRLU024	60	0.20 0.10	8.5 16	31 64	141 143	 I-Pak TO-251AA
IRLU110 IRLU120	100	0.54 0.27	4.6 8.4	18 31	145 147	




# Selection Guide


## SOT-89

Part Number	$BV_{DSS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRFS1Z0	100	2.4	0.90	3.6	131	 SOT-89

## D-Pak N-Channel


Part Number	$BV_{DSS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRFR014	60	0.20	8.4	34	63	 D-Pak TO-252AA
IRFR024		0.10	16	64	69	
IRFR110	100	0.54	4.7	19	75	
IRFR120		0.27	8.4	34	81	
IRFR210	200	1.5	2.7	8.0	87	
IRFR220		0.80	4.8	18	95	
IRFR214	250	2.0	2.2	8.8	89	
IRFR224		1.1	3.8	14	97	
IRFR310	400	3.6	1.7	5.0	99	
IRFR320		1.8	3.1	11	101	
IRFR420	500	3.0	2.4	8.0	103	
IRFRC20	600	4.4	2.0	8.0	129	

## D-Pak P-Channel


Part Number	$BV_{DSS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRFR9014	-60	0.50	-5.6	-22	105	 D-Pak TO-252AA
IRFR9024		0.28	-9.6	-38	111	
IRFR9110	-100	1.2	-3.4	-14	117	
IRFR9120		0.60	-6.3	-25	119	
IRFR9210	-200	3.0	-2.0	-8.0	125	
IRFR9220		1.5	-3.6	-14	127	

# Selection Guide


## DIP N-Channel

Part Number	$BV_{DS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRFD014	60	0.20	1.7	14	1	 HD-1
IRFD024		0.10	2.5	20	7	
IRFD1Z0	100	2.4	0.50	4.0	25	
IRFD110		0.54	1.0	8.0	13	
IRFD120		0.27	1.3	10	19	
IRFD210	200	1.5	0.60	4.8	31	
IRFD220		0.80	0.80	6.4	37	

## DIP P-Channel


Part Number	$BV_{DS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRFD9014	-60	0.50	-1.1	-8.8	39	 HD-1
IRFD9024		0.28	-1.6	-13	41	
IRFD9110	-100	1.2	-0.70	-5.6	47	
IRFD9120		0.60	-1.0	-8.0	53	
IRFD9210	-200	3.0	-0.4	-3.2	59	
IRFD9220		1.5	-0.58	-4.6	61	

## I-Pak N-Channel

Part Number	$BV_{DS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRFU014	60	0.20	8.4	34	63	 I-Pak TO-251AA
IRFU024		0.10	16	64	69	
IRFU110	100	0.54	4.7	19	75	
IRFU120		0.27	8.4	34	81	
IRFU210	200	1.5	2.7	8.0	87	
IRFU220		0.80	4.8	18	95	
IRFU214	250	2.0	2.2	8.8	89	
IRFU224		1.1	3.8	14	97	
IRFU310	400	3.6	1.7	5.0	99	
IRFU320		1.8	3.1	11	101	
IRFU420	500	3.0	2.4	8.0	103	
IRFUC20	600	4.4	2.0	8.0	129	

# Selection Guide

## I-Pak P-Channel

Part Number	$BV_{DS}$ Drain-to-Source Breakdown (Volts)	$R_{DS(on)}$ Drain-to-Source On Resistance ( $\Omega$ )	$I_D$ Continuous Drain Current 25°C (Amps)	$I_{DM}$ Max. Pulsed Drain Current (Amps)	Page Number	Case Style
IRFU9014	-60	0.50	-5.6	-22	105	 I-Pak TO-251AA
IRFU9024		0.28	-9.6	-38	111	
IRFU9110	-100	1.2	-3.4	-14	117	
IRFU9120		0.60	-6.3	-25	119	
IRFU9210	-200	3.0	-2.0	-8.0	125	
IRFU9220		1.5	-3.6	-14	127	

## Data Sheets

The HEXFET devices listed in this Designer's Manual represent International Rectifier's power MOSFET line as of June, 1991. The data presented in this manual supersedes all previous specifications.

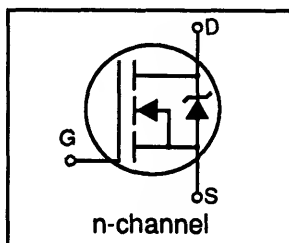
In the interest of product improvement, International Rectifier reserves the right to change specifications without notice.

# International Rectifier

# IRFD014

## HEXFET® Power MOSFET

- Dynamic dv/dt Rated
- For Automatic Insertion
- End Stackable



$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.20 $\Omega$   
 $I_D$  1.7A

## Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1

## Absolute Maximum Ratings

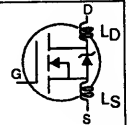
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.7	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.2	
$I_{DM}$	Pulsed Drain Current ①	14	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	130	mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

## Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W④

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

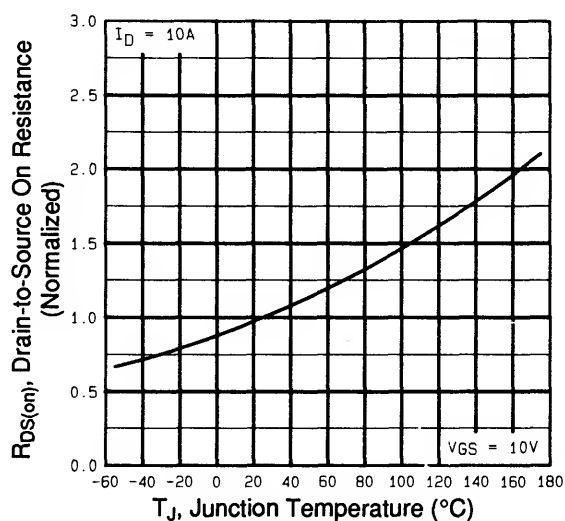
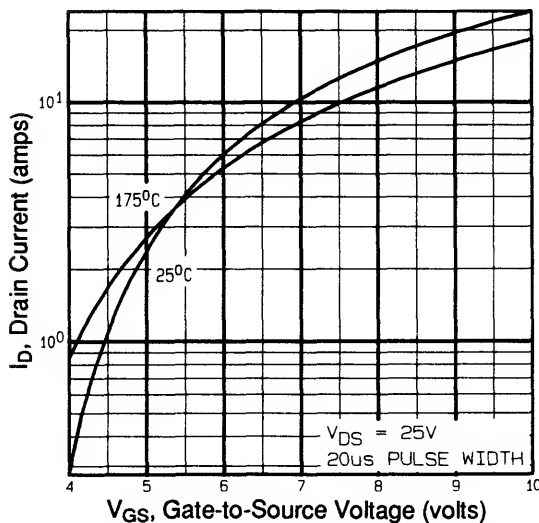
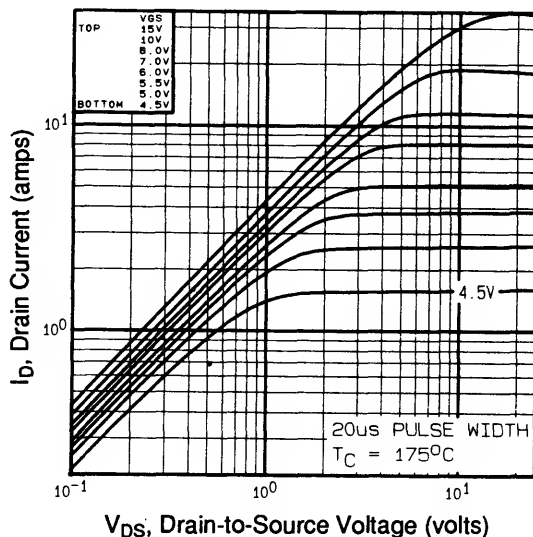
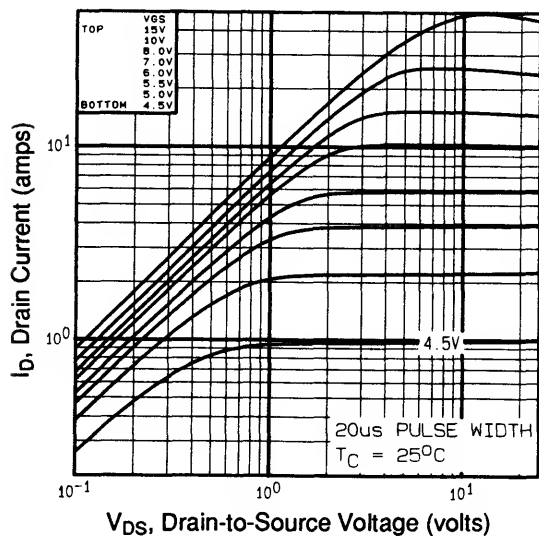
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.063	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.20	$\Omega$	$V_{GS}=10V$ , $I_D=1.0A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.3	---	---	S	$V_{DS}=25V$ , $I_{DS}=1.0A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=48V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	11	nC	$I_D=10A$ , $V_{DS}=48V$ , $V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.1		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	5.8		
$t_{d(on)}$	Turn-On Delay Time	---	10	---	ns	$V_{DD}=30V$ , $I_D=10A$ $R_G=24\Omega$ , $R_D=2.7\Omega$ See Fig. 10④
$t_r$	Rise Time	---	50	---		
$t_{d(off)}$	Turn-Off Delay Time	---	13	---		
$t_f$	Fall Time	---	19	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	310	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0Mhz$ See Fig. 5
$C_{oss}$	Output Capacitance	---	160	---		
$C_{rss}$	Reverse Transfer Capacitance	---	37	---		

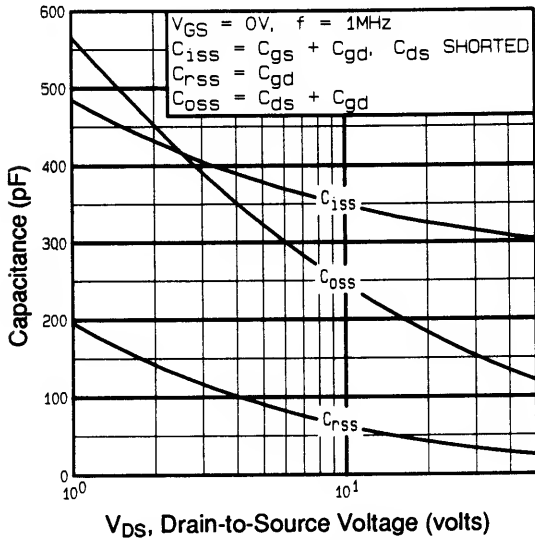

**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	1.7	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	14		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}$ , $I_S=1.7A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	34	---	140	ns	$T_J=25^\circ\text{C}$ , $I_F=10A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.090	---	0.40	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

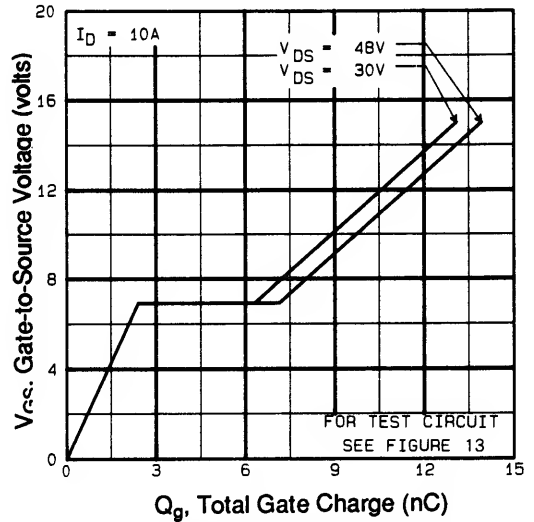
**Notes:**

- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=55mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=1.7A$  (See figure 12)
- ③  $I_{SD}\leq 10A$ ,  $di/dt\leq 90A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ C/W$

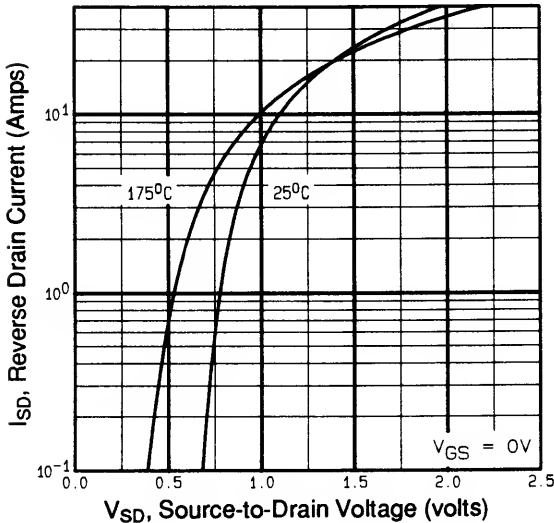




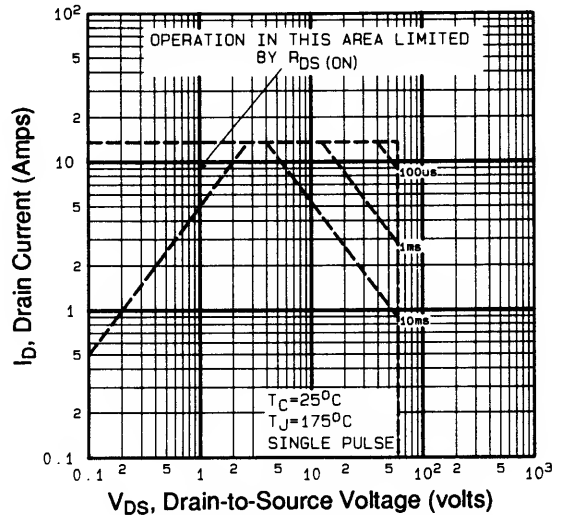
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



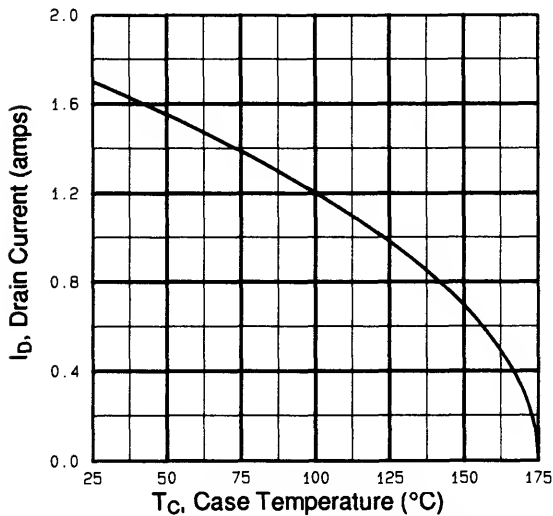
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



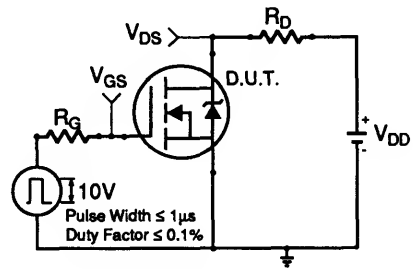
**Fig 7. Typical Source-Drain Diode Forward Voltage**



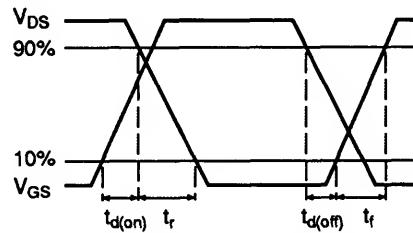
**Fig 8. Maximum Safe Operating Area**



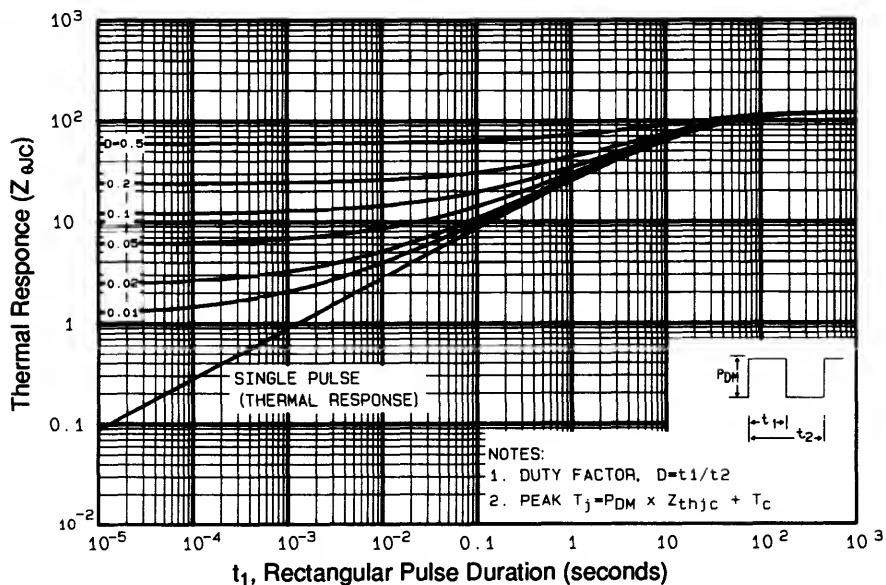
**Fig 9. Maximum Drain Current Vs. Case Temperature**



**Fig 10a. Switching Time Test Circuit**

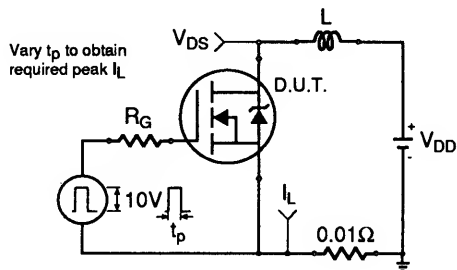


**Fig 10b. Switching Time Waveforms**

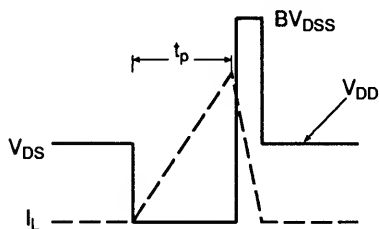


**Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case**

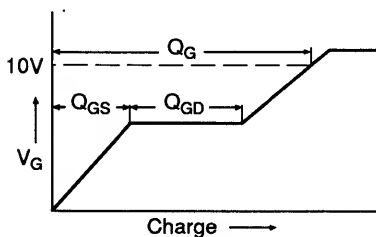




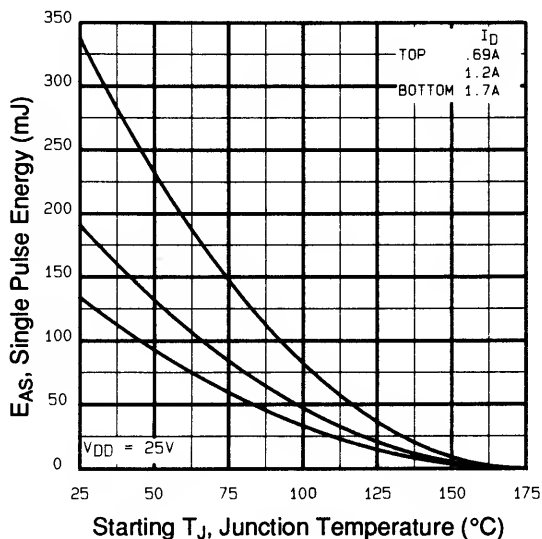
**Fig 12a.** Unclamped Inductive Test Circuit



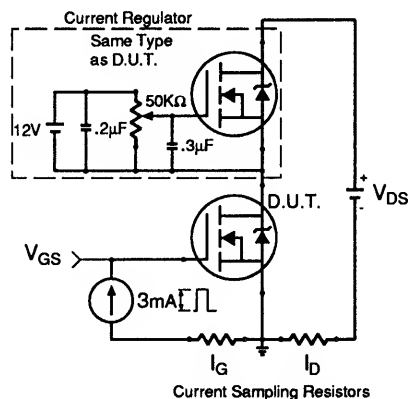
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

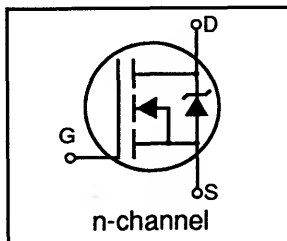
**Appendix D:** Part Marking Information

# International Rectifier

## IRFD024

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable



$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.10 $\Omega$   
 $I_D$  2.5A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1

### Absolute Maximum Ratings

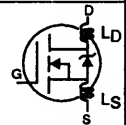
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	2.5	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.8	
$I_{DM}$	Pulsed Drain Current ①	20	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	91	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W④

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.061	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.10	$\Omega$	$V_{GS}=10V$ , $I_D=1.5A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	2.7	---	---	S	$V_{DS}=25V$ , $I_{DS}=1.5A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=48V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	28	nC	$I_D=14A$ , $V_{DS}=48V$ , $V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	5.4		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	13		
$t_{d(on)}$	Turn-On Delay Time	---	8.6	---	ns	$V_{DD}=30V$ , $I_D=14A$ $R_G=18\Omega$ , $R_D=2.0\Omega$ See Fig. 10④
$t_r$	Rise Time	---	47	---		
$t_{d(off)}$	Turn-Off Delay Time	---	27	---		
$t_f$	Fall Time	---	37	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	640	---	pF	$V_{GS}=0V$ , $V_{DS}=25v$ $f=1.0Mhz$ See Fig. 5
$C_{oss}$	Output Capacitance	---	360	---		
$C_{rss}$	Reverse Transfer Capacitance	---	79	---		

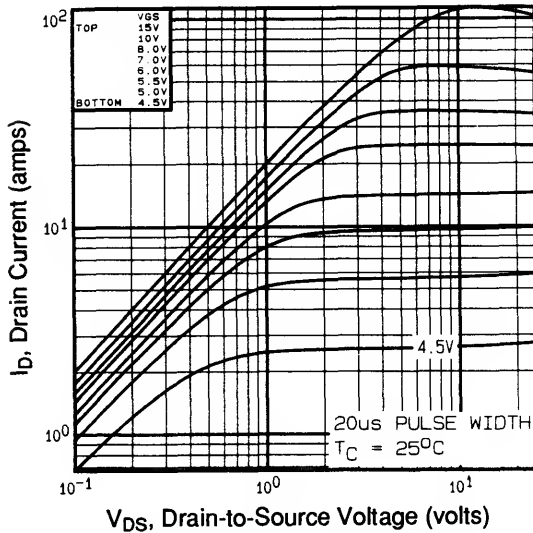


## Source-Drain Diode Ratings and Characteristics

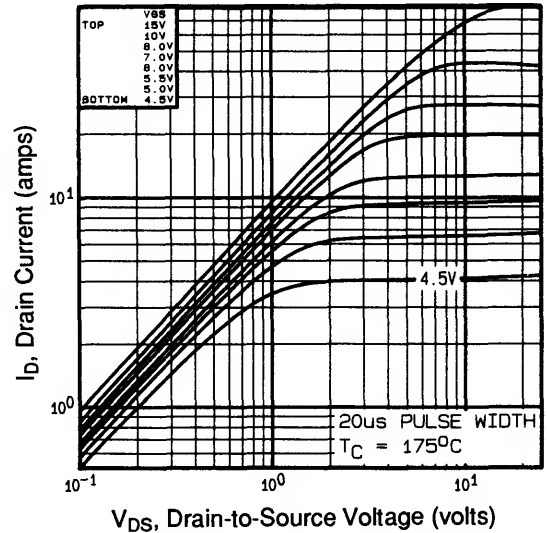
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	2.5	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	20		
$V_{SD}$	Diode Forward Voltage	---	---	1.5	V	$T_J=25^\circ\text{C}$ , $I_S=2.5A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	49	---	200	ns	$T_J=25^\circ\text{C}$ , $I_F=14A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.22	---	0.88	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

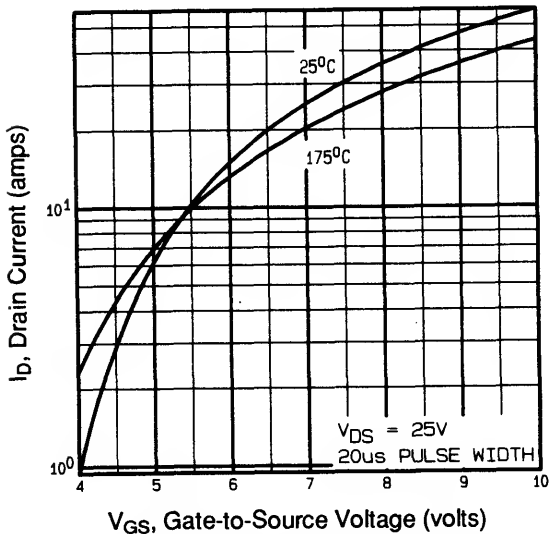
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=17.5mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.5A$  (See figure 12)
- ③  $I_{SD}\leq 14A$ ,  $di/dt\leq 110A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ C/W$



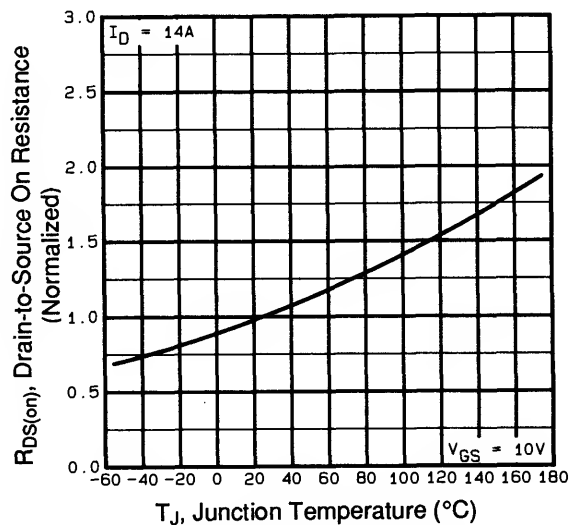
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



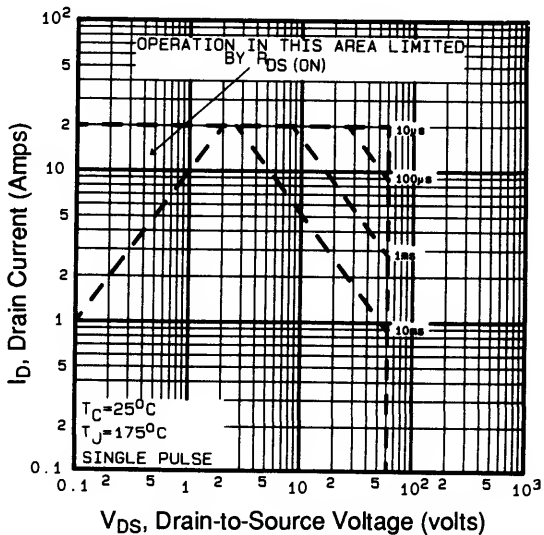
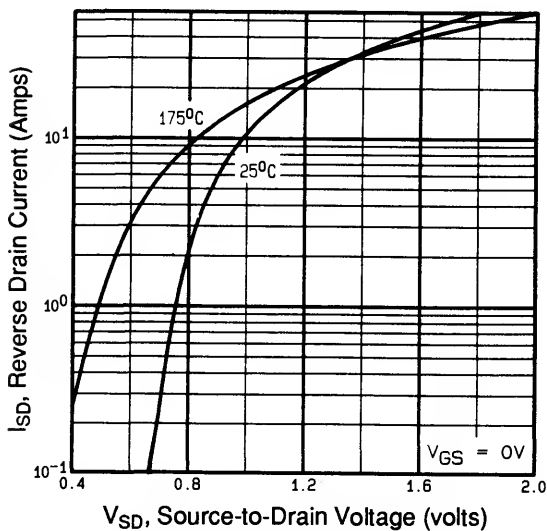
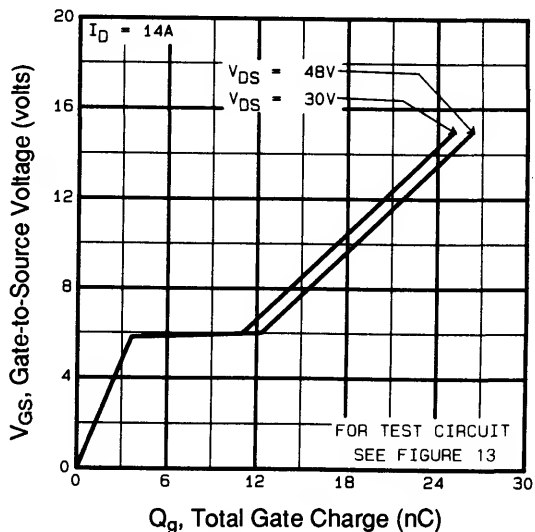
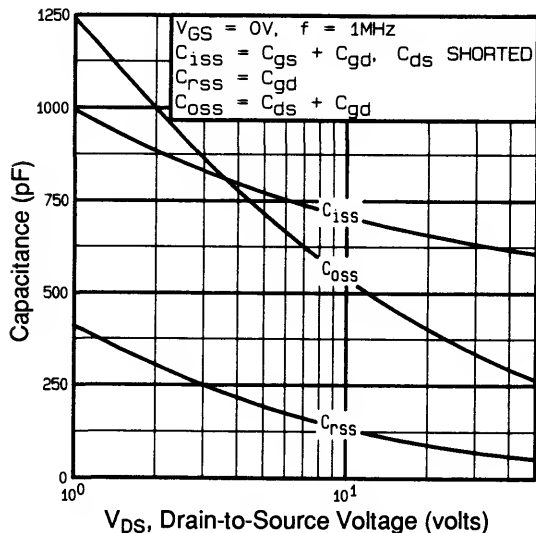
**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$

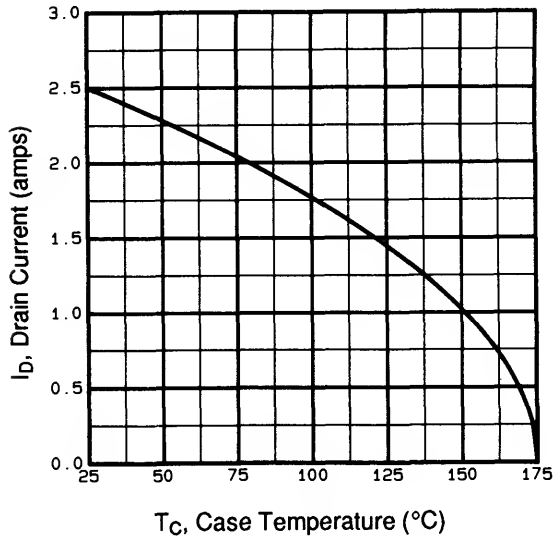


**Fig 3. Typical Transfer Characteristics**

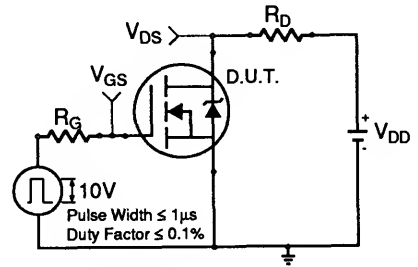


**Fig 4. Normalized On-Resistance Vs.**  
Temperature

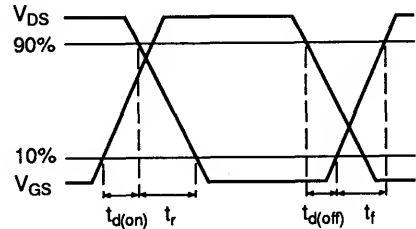




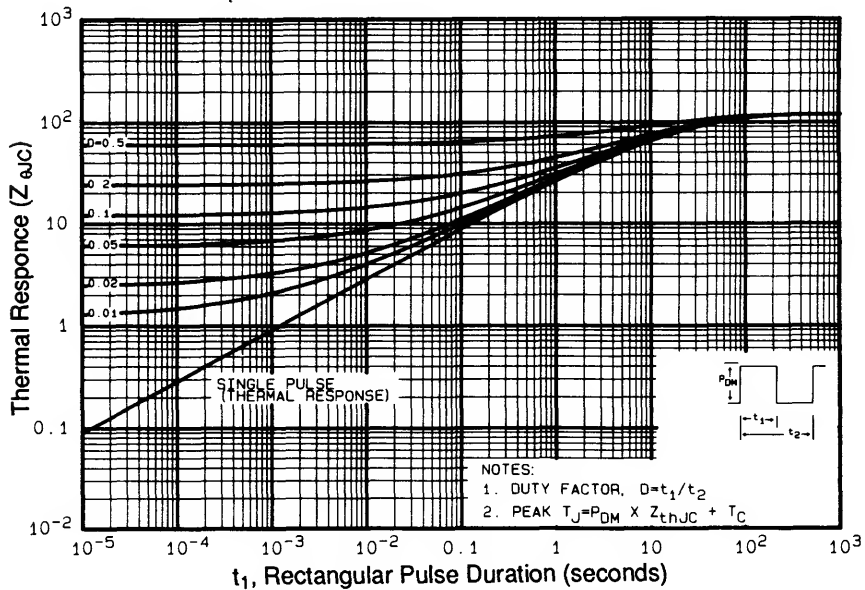
**Fig 9.** Maximum Drain Current Vs. Case Temperature



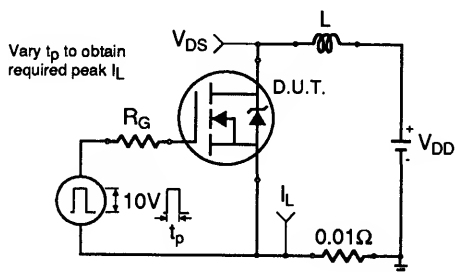
**Fig 10a.** Switching Time Test Circuit



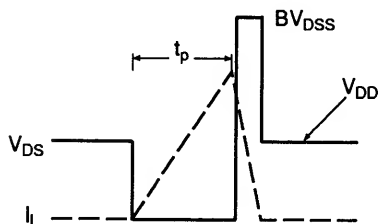
**Fig 10b.** Switching Time Waveforms



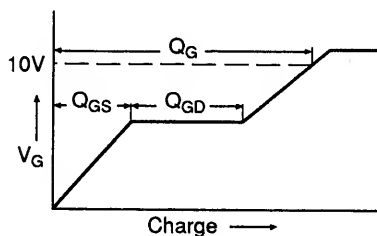
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



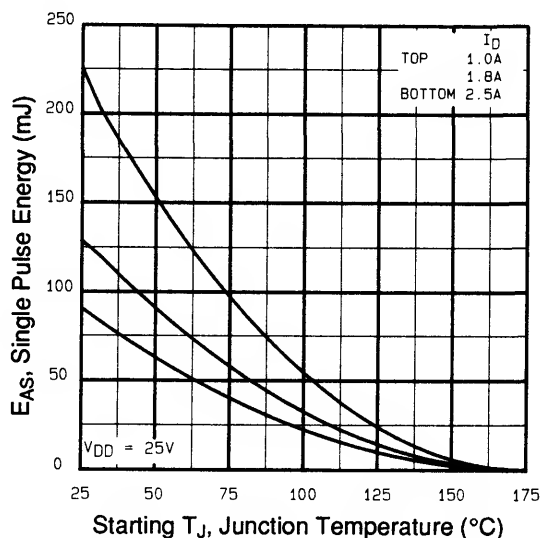
**Fig 12a.** Unclamped Inductive Test Circuit



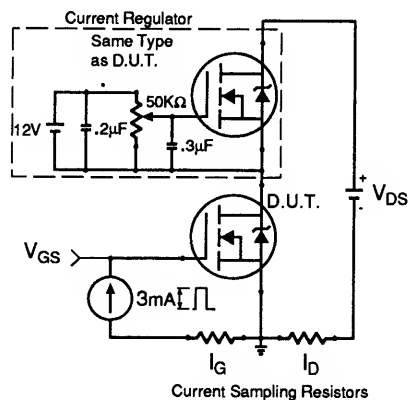
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

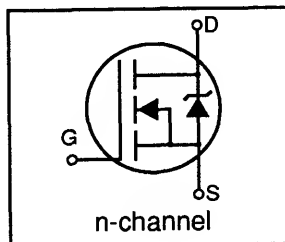
**Appendix D:** Part Marking Information

# International Rectifier

## IRFD110

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable

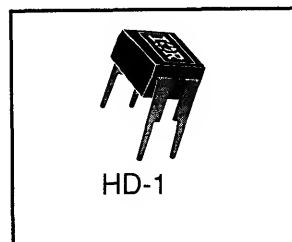


$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.54 $\Omega$   
 $I_D$  1.0A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.0	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.71	
$I_{DM}$	Pulsed Drain Current ①	8.0	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	1.0	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

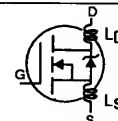
### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W②



**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

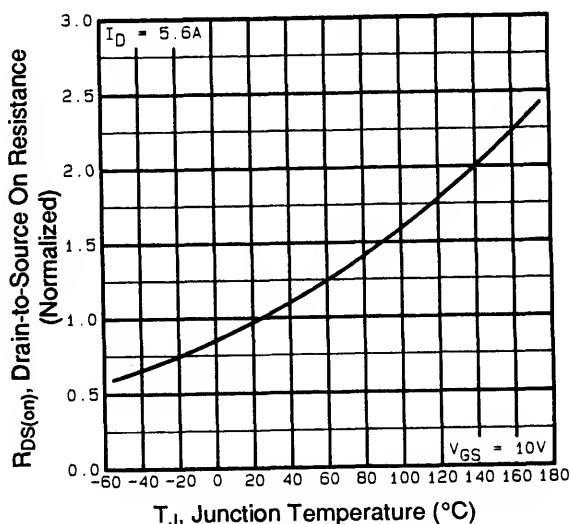
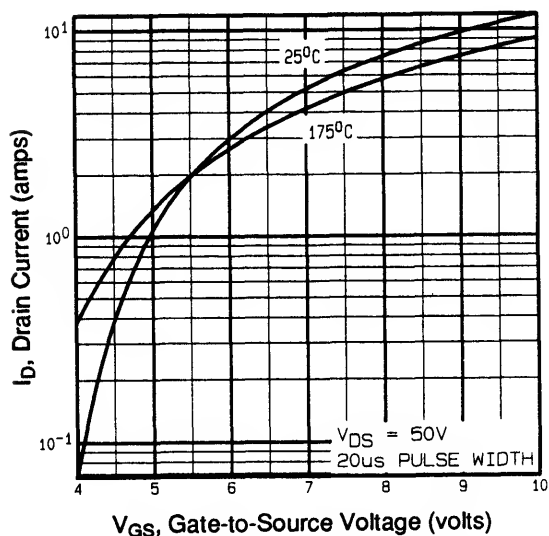
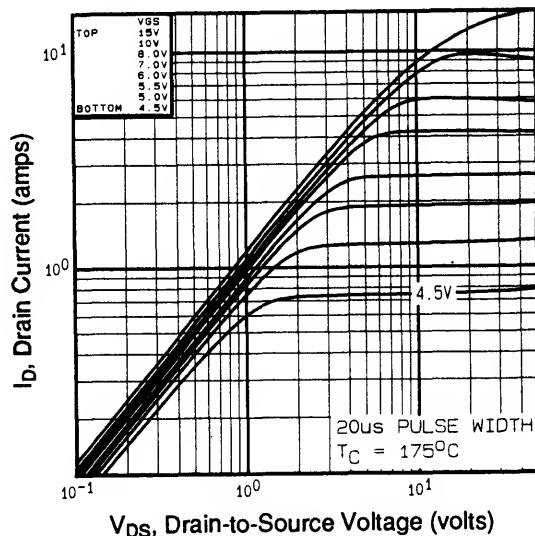
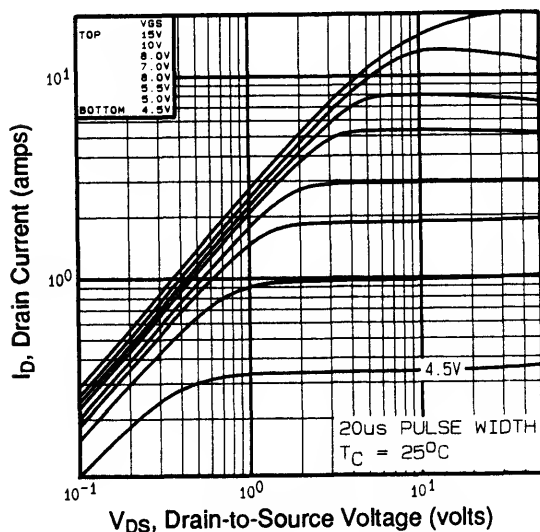
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.54	$\Omega$	$V_{GS}=10V, I_D=0.60A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.80	---	---	S	$V_{DS}=50V, I_{DS}=0.60A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V, V_{GS}=0V$
		---	---	1000		$V_{DS}=80V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	8.3	nC	$I_D=5.6A, V_{DS}=80V, V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.3		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	3.8		
$t_{d(on)}$	Turn-On Delay Time	---	6.9	---	ns	$V_{DD}=50V, I_D=5.6A$ $R_G=24\Omega, R_D=8.4\Omega$ See Fig. 10④
$t_r$	Rise Time	---	16	---		
$t_{d(off)}$	Turn-Off Delay Time	---	15	---		
$t_f$	Fall Time	---	9.4	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	180	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	81	---		
$C_{rss}$	Reverse Transfer Capacitance	---	15	---		

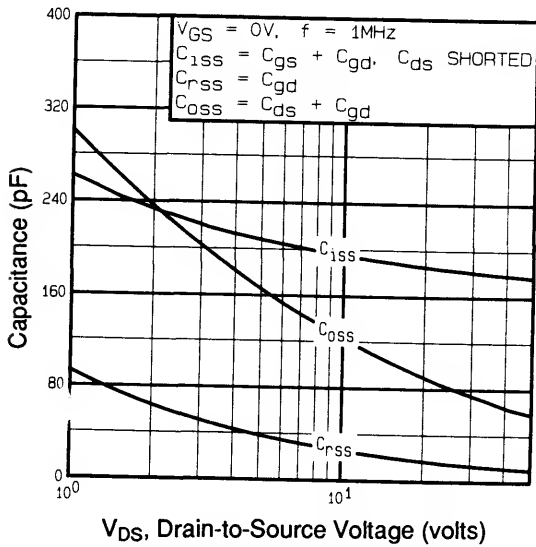

**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	1.0	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	8.0		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}, I_S=1.0A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	50	---	200	ns	$T_J=25^\circ\text{C}, I_F=5.6A,$ $di/dt=100A/\mu s$ ④
$Q_{RR}$	Reverse Recovery Charge	0.22	---	0.88	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

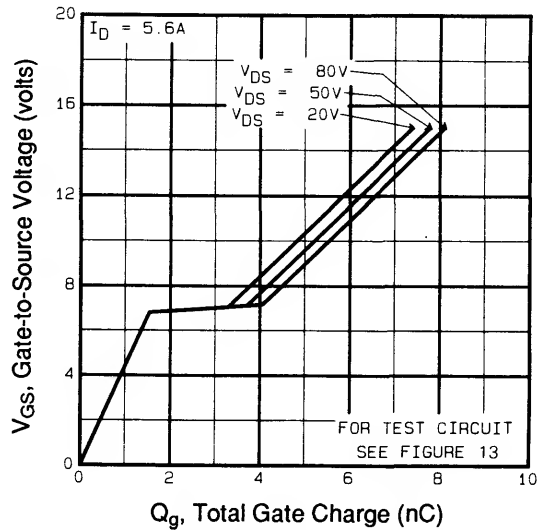
**Notes:**

- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=52\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.0A$  (See figure 12)
- ③  $I_{SD} \leq 5.6A$ ,  $di/dt \leq 75A/\mu s$ ,  $V_{DD} \leq BV_{DSS}$ ,  $T_J \leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

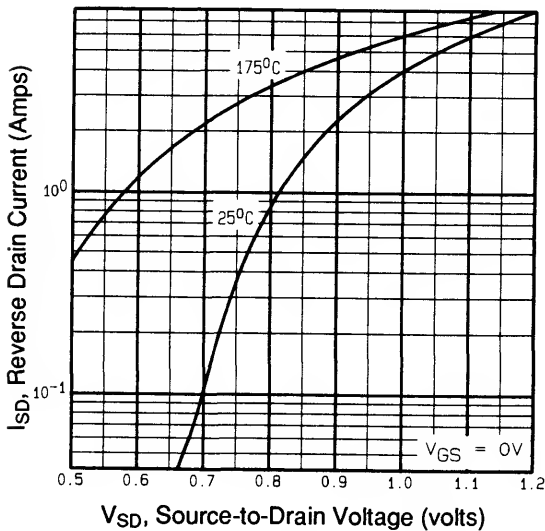




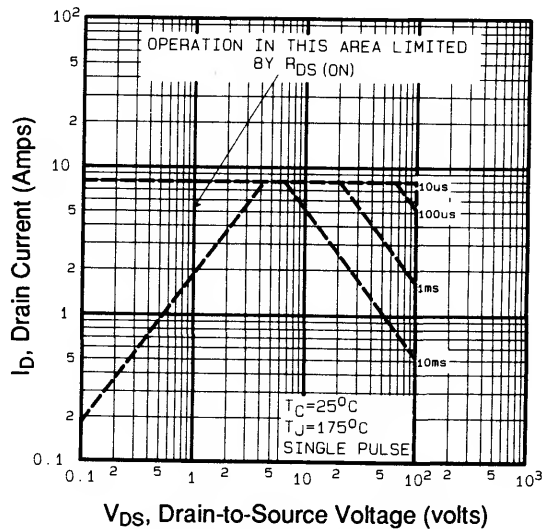
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



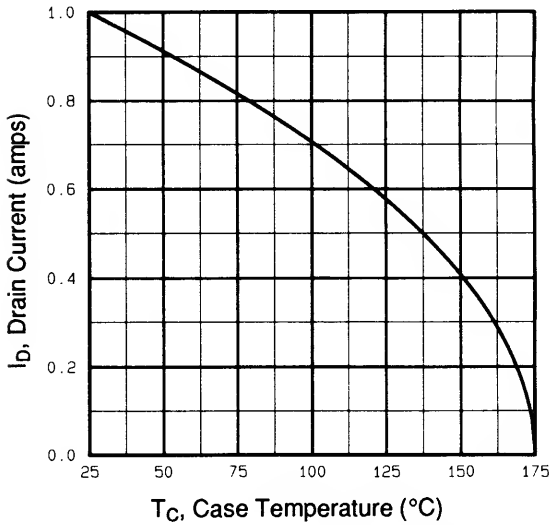
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



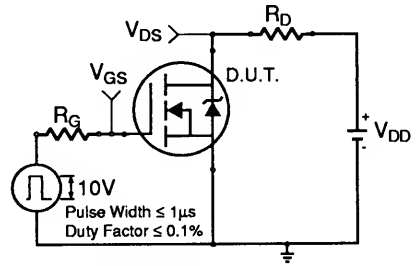
**Fig 7. Typical Source-Drain Diode Forward Voltage**



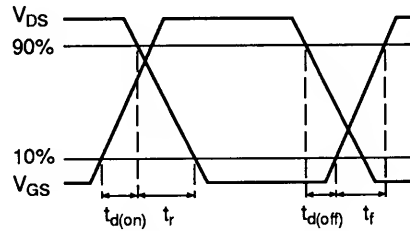
**Fig 8. Maximum Safe Operating Area**



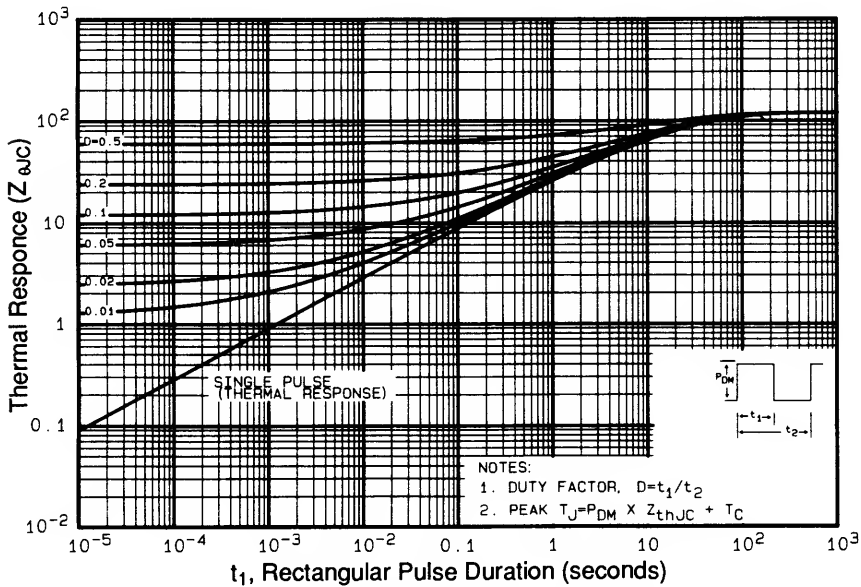
**Fig 9.** Maximum Drain Current Vs. Case Temperature



**Fig 10a.** Switching Time Test Circuit



**Fig 10b.** Switching Time Waveforms



**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

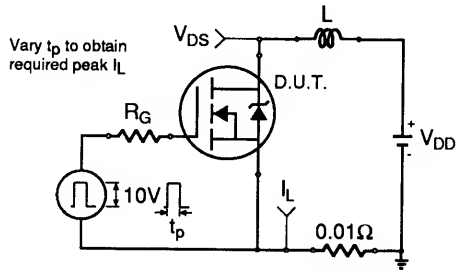


Fig 12a. Unclamped Inductive Test Circuit

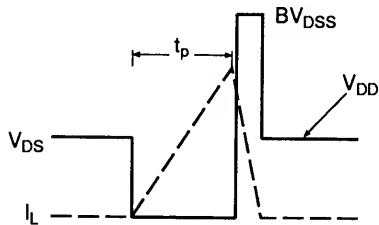


Fig 12b. Unclamped Inductive Waveforms

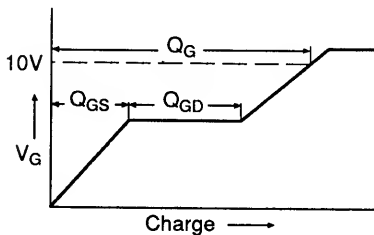


Fig 13a. Basic Gate Charge Waveform

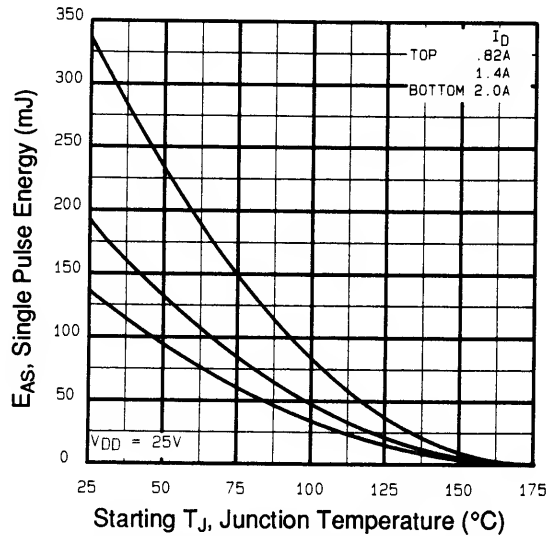


Fig 12c. Maximum Avalanche Energy vs. Drain Current

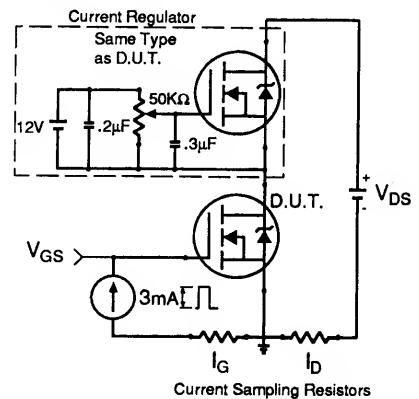


Fig 13b. Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

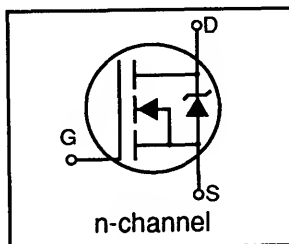
**Appendix D:** Part Marking Information

# International Rectifier

# IRFD120

## HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable

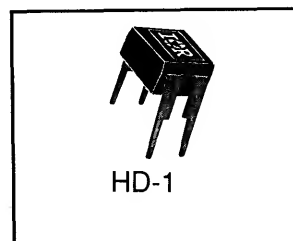


$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.27 $\Omega$   
 $I_D$  1.3A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



### Absolute Maximum Ratings

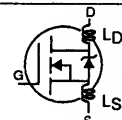
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.3	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.94	
$I_{DM}$	Pulsed Drain Current ①	10	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	100	mJ
$I_{AR}$	Avalanche Current ①	1.3	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

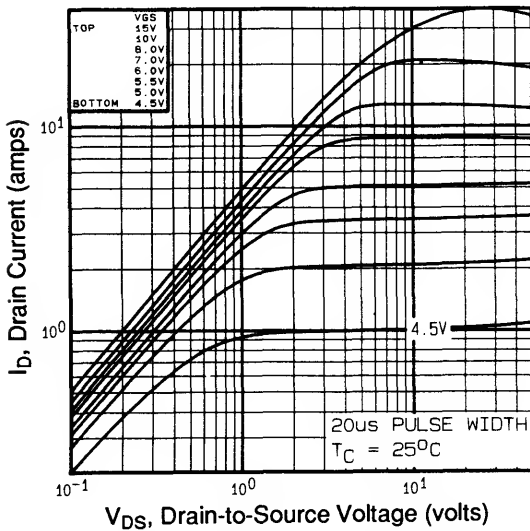
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.13	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.27	$\Omega$	$V_{GS}=10V$ , $I_D=0.78A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.80	---	---	S	$V_{DS}=50V$ , $I_{DS}=0.78A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	$nA$	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	16		$I_D=9.2A$ , $V_{DS}=80V$ , $V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	4.4	$nC$	
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.7		
$t_{d(on)}$	Turn-On Delay Time	---	6.8	---	ns	$V_{DD}=50V$ , $I_D=9.2A$ $R_G=18\Omega$ , $R_D=5.2\Omega$ See Fig. 10④
$t_r$	Rise Time	---	27	---		
$t_{d(off)}$	Turn-Off Delay Time	---	18	---		
$t_f$	Fall Time	---	17	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	360	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	150	---		
$C_{rss}$	Reverse Transfer Capacitance	---	34	---		


**Source-Drain Diode Ratings and Characteristics**

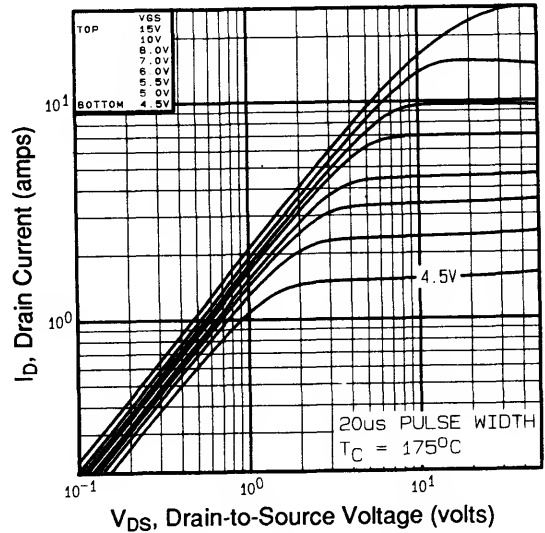
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	1.3	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	10		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}$ , $I_S=1.3A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	65	---	260	ns	$T_J=25^\circ\text{C}$ , $I_F=9.2A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.33	---	1.3	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

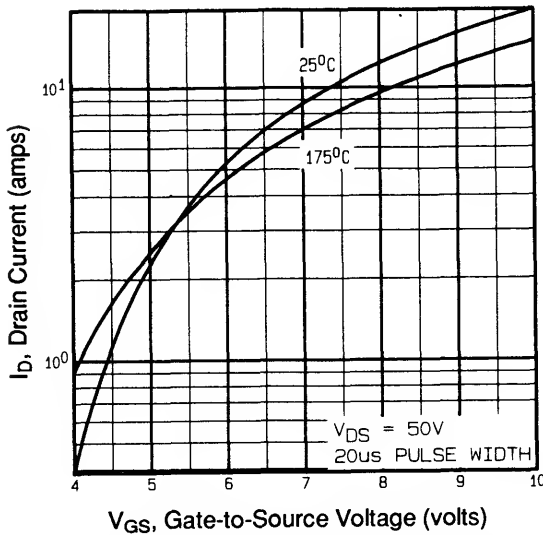
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=24\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.6A$  (See figure 12)
- ③  $I_{SD}\leq 9.2A$ ,  $di/dt\leq 110A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$



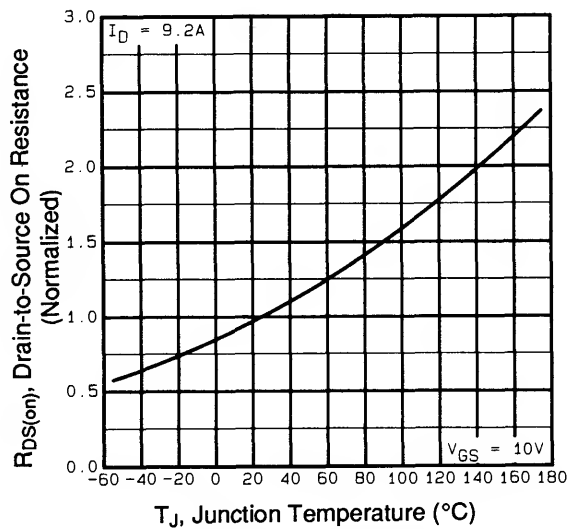
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$

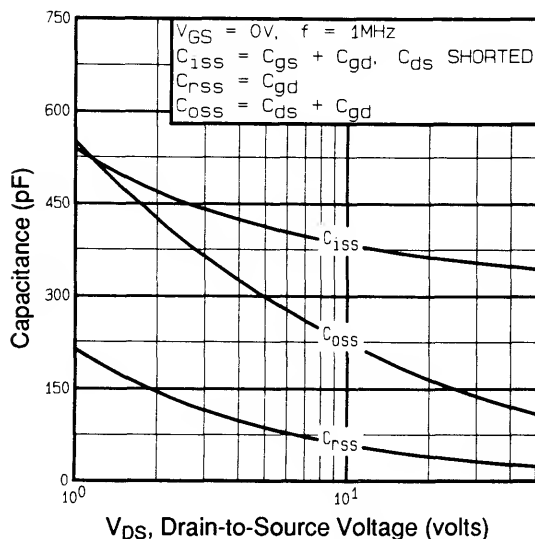


**Fig 3. Typical Transfer Characteristics**

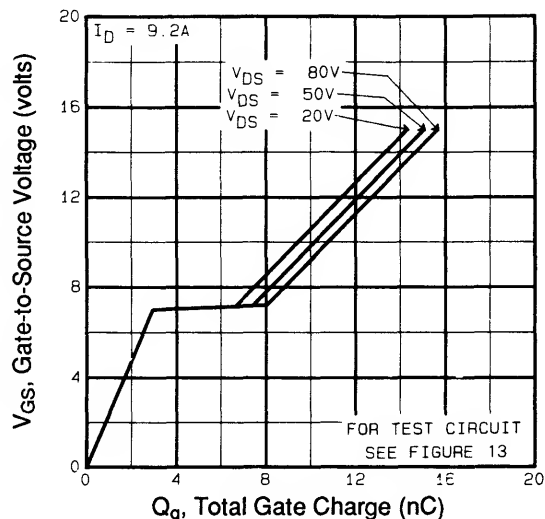


**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**

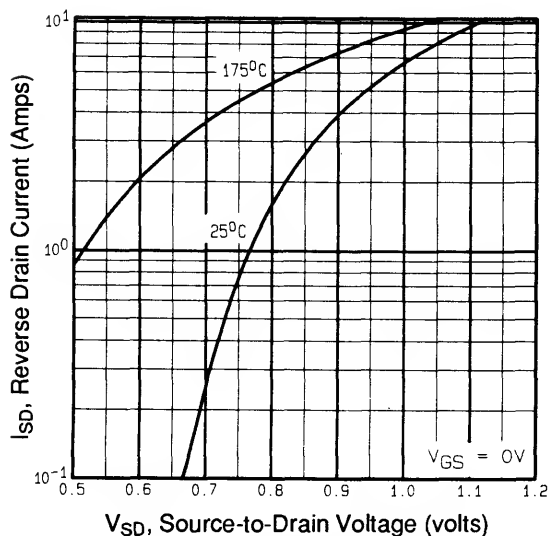




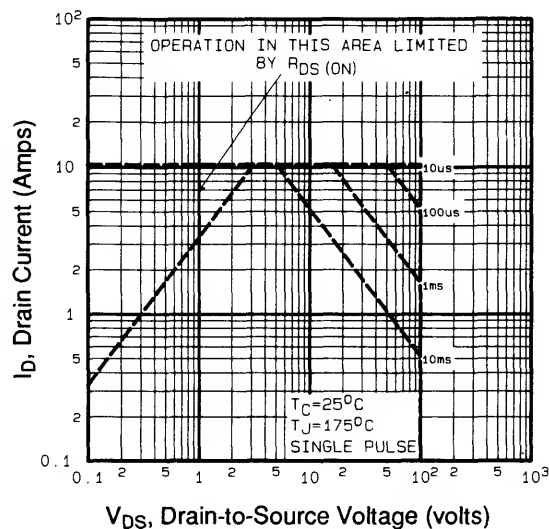
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



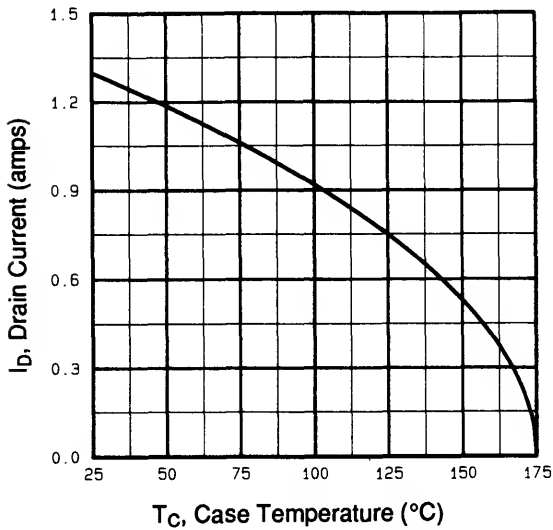
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



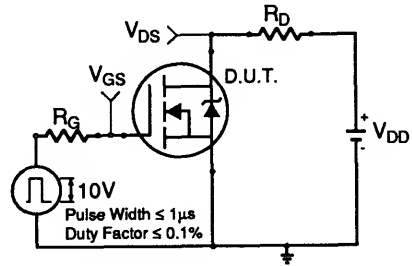
**Fig 7. Typical Source-Drain Diode Forward Voltage**



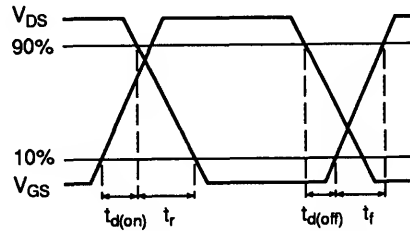
**Fig 8. Maximum Safe Operating Area**



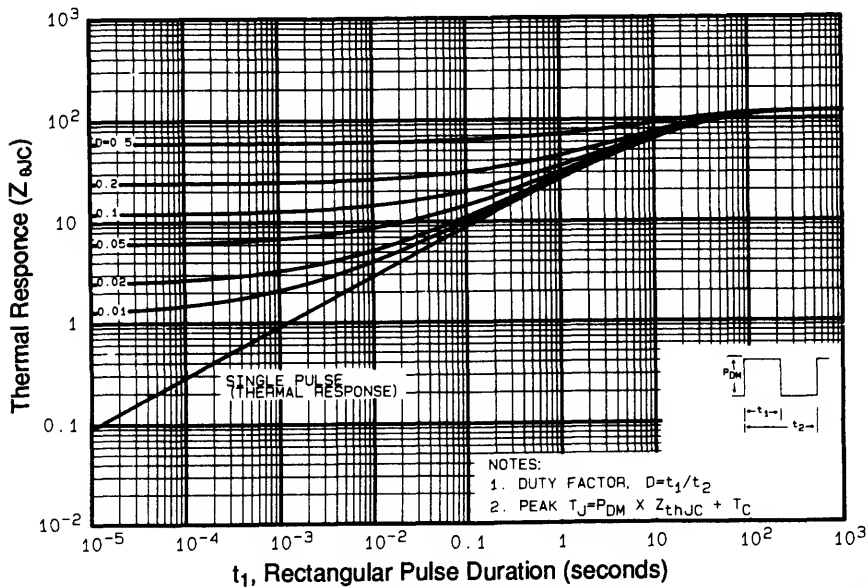
**Fig 9.** Maximum Drain Current Vs. Case Temperature



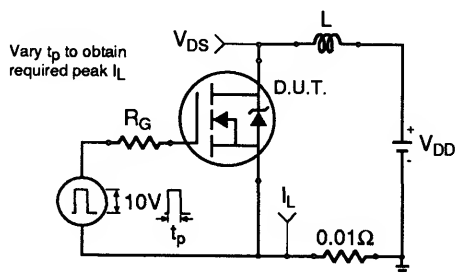
**Fig 10a.** Switching Time Test Circuit



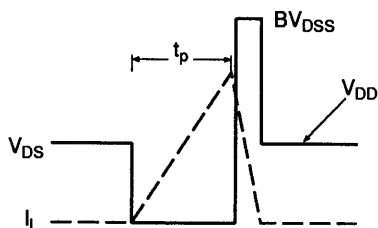
**Fig 10b.** Switching Time Waveforms



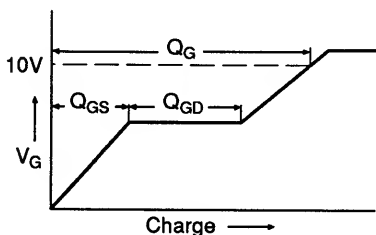
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



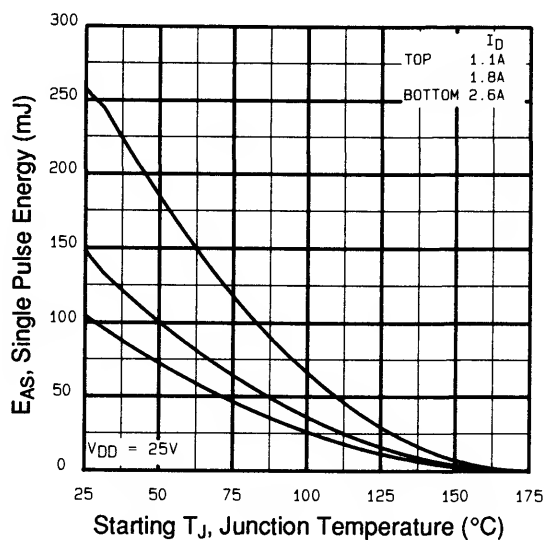
**Fig 12a. Unclamped Inductive Test Circuit**



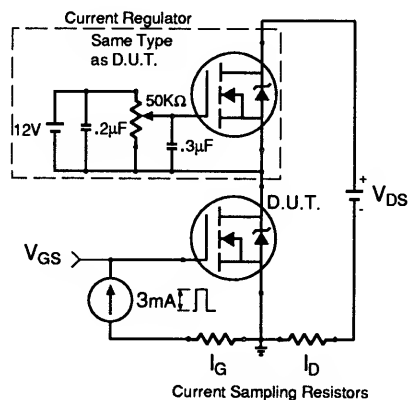
**Fig 12b. Unclamped Inductive Waveforms**



**Fig 13a. Basic Gate Charge Waveform**



**Fig 12c. Maximum Avalanche Energy vs. Drain Current**



**Fig 13b. Gate Charge Test Circuit**

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

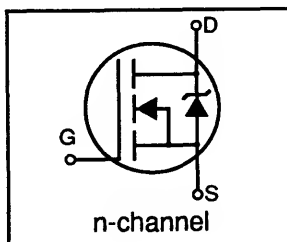
**Appendix D:** Part Marking Information

# International Rectifier

## IRFD1Z0

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable

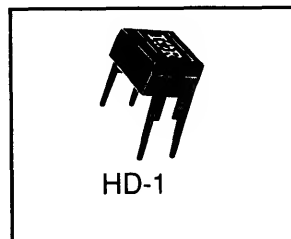


$BV_{DSS}$  100V  
 $R_{DS(on)}$  2.4 $\Omega$   
 $I_D$  0.50A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



### Absolute Maximum Ratings

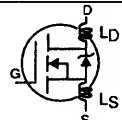
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.50	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.36	
$I_{DM}$	Pulsed Drain Current ①	4.0	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.25	W
	Linear Derating Factor	0.10	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	9.8	mJ
$I_{AR}$	Avalanche Current ①	0.50	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	2.4	$\Omega$	$V_{GS}=10V$ , $I_D=0.30A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.60	---	---	S	$V_{DS}=50V$ , $I_{DS}=0.30A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	1.6	nC	$I_D=0.9A$ , $V_{DS}=80V$ , $V_{GS}=10V$
$Q_{gs}$	Gate-to-Source Charge	---	---	0.68		See Fig 6 and 13④
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	0.95		
$t_{d(on)}$	Turn-On Delay Time	---	7.8	---	ns	$V_{DD}=50V$ , $I_D=0.9A$
$t_r$	Rise Time	---	4.5	---		$R_G=50\Omega$ , $R_D=55\Omega$
$t_{d(off)}$	Turn-Off Delay Time	---	11	---		See Fig. 10④
$t_f$	Fall Time	---	4.7	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	39	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$
$C_{oss}$	Output Capacitance	---	18	---		$f=1.0Mhz$
$C_{rss}$	Reverse Transfer Capacitance	---	2.8	---		See Fig. 5

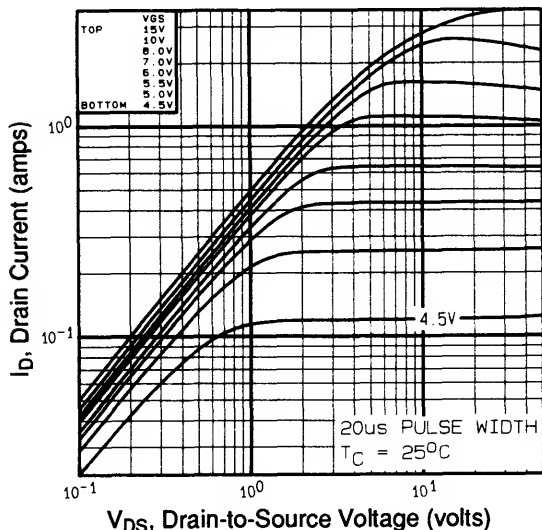


## Source-Drain Diode Ratings and Characteristics

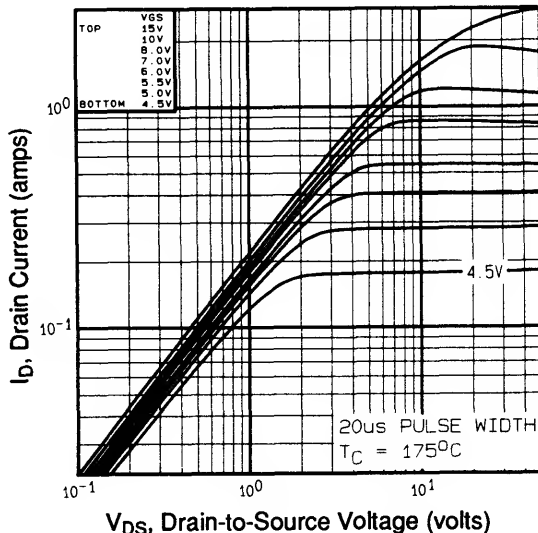
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	0.5	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	4.0		
$V_{SD}$	Diode Forward Voltage	---	---	1.4	V	$T_J=25^\circ\text{C}$ , $I_S=0.5A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	42	---	71	ns	$T_J=25^\circ\text{C}$ , $I_F=0.9A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.14	---	0.41	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

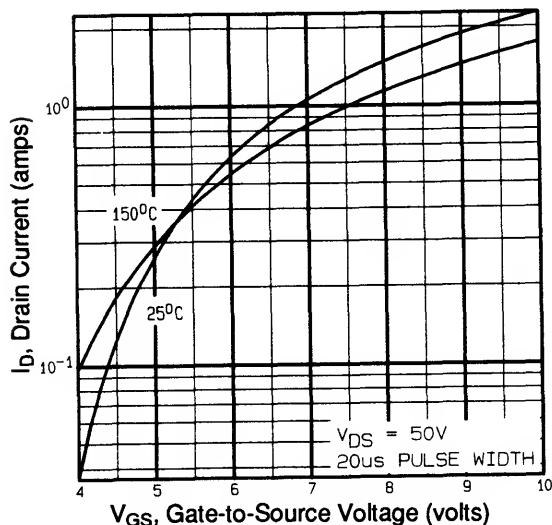
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=16mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=1.0A$  (See figure 12)
- ③  $I_{SD} \leq 0.5A$ ,  $di/dt \leq 25A/\mu s$ ,  $V_{DD} \leq BV_{DSS}$ ,  $T_J \leq 175^\circ\text{C}$  Suggested  $R_G=50\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$



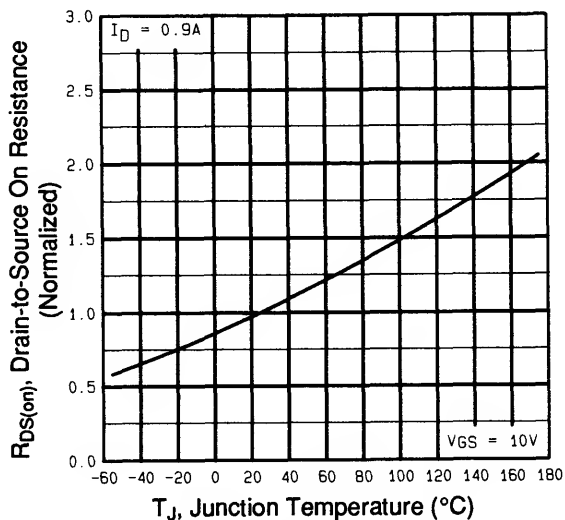
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^{\circ}\text{C}$



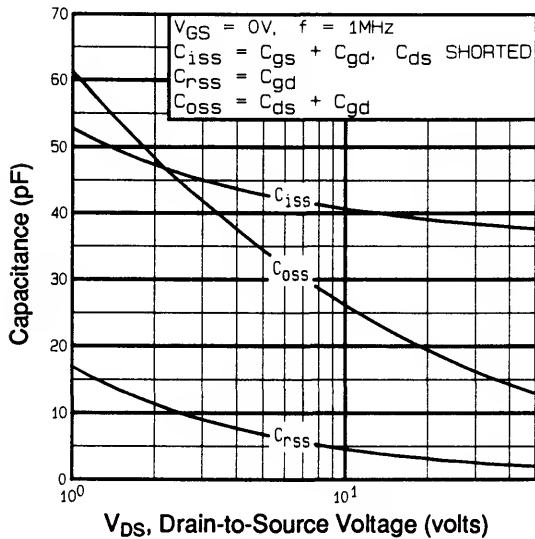
**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^{\circ}\text{C}$



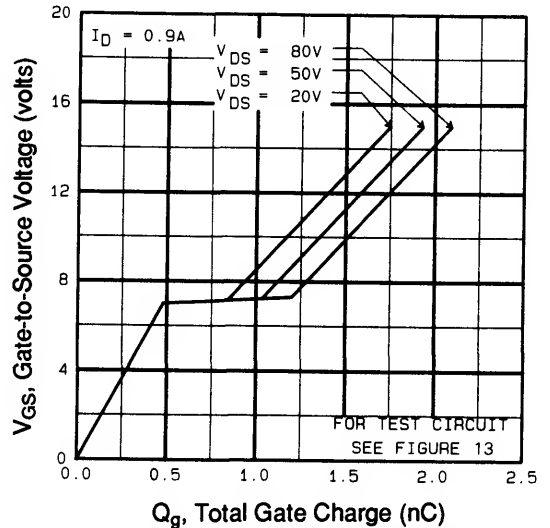
**Fig 3. Typical Transfer Characteristics**



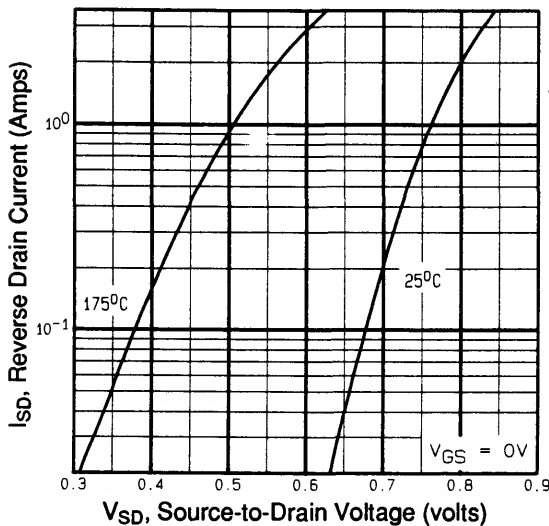
**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**



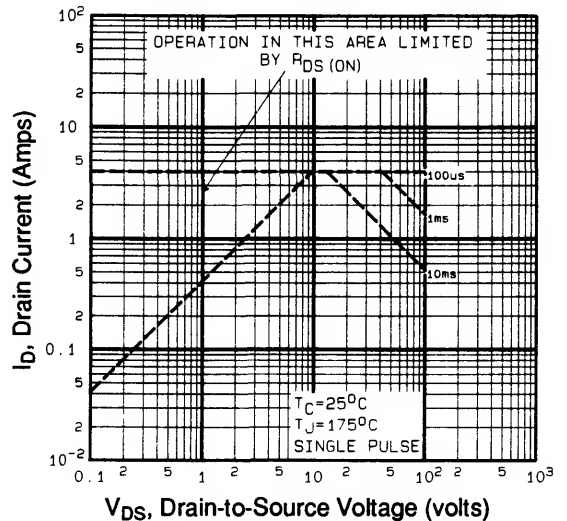
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



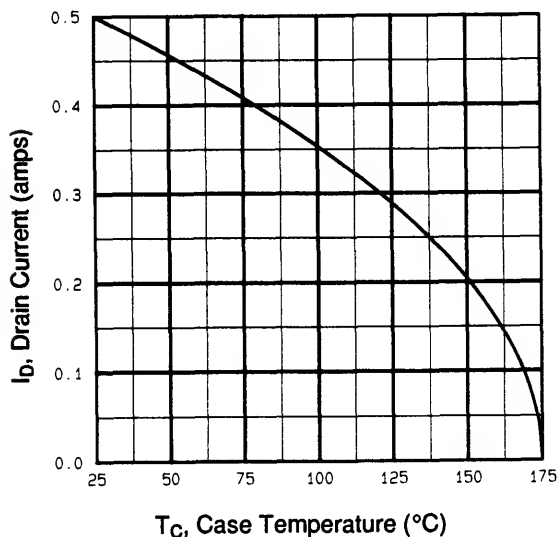
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



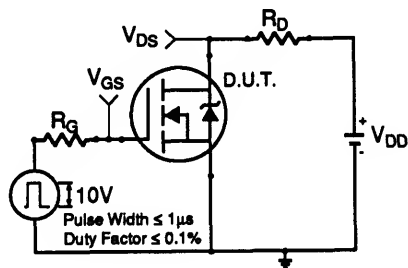
**Fig 7. Typical Source-Drain Diode Forward Voltage**



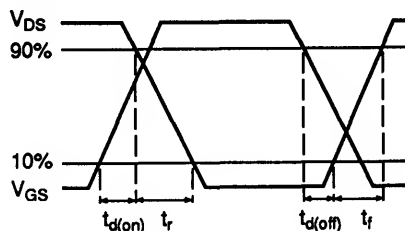
**Fig 8. Maximum Safe Operating Area**



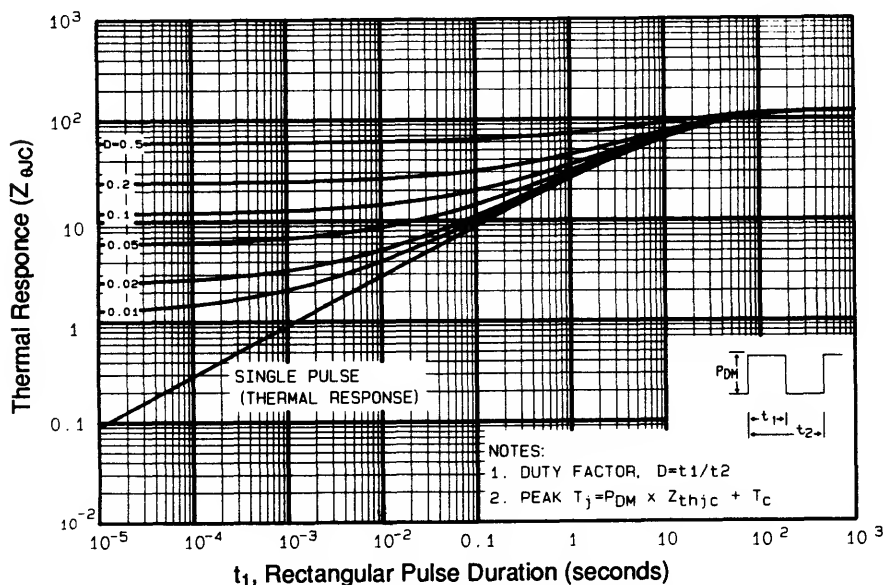
**Fig 9.** Maximum Drain Current Vs. Case Temperature



**Fig 10a.** Switching Time Test Circuit

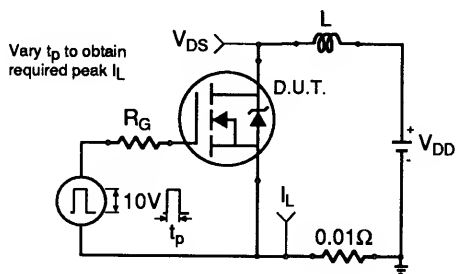


**Fig 10b.** Switching Time Waveforms

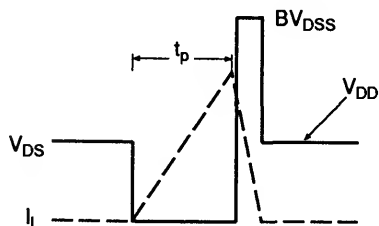


**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

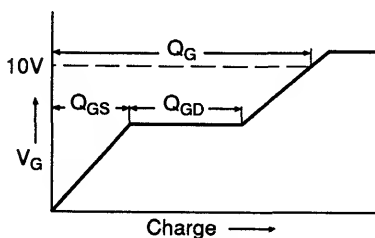




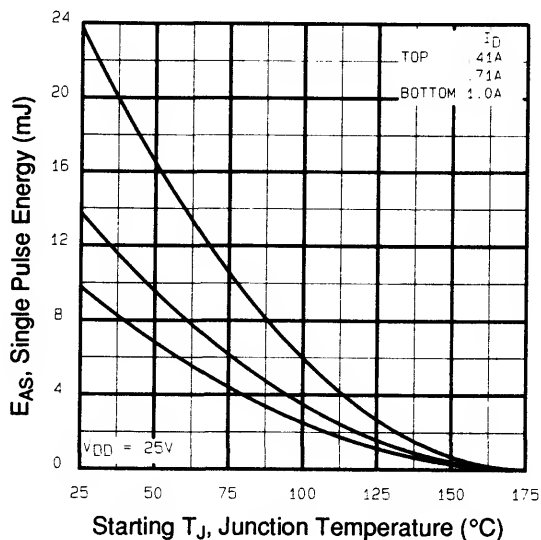
**Fig 12a.** Unclamped Inductive Test Circuit



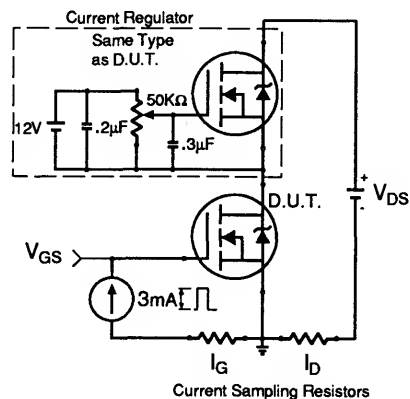
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

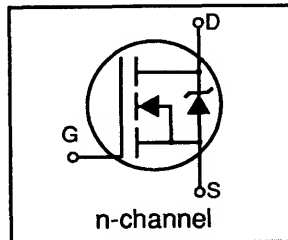
**Appendix D:** Part Marking Information

# International Rectifier

## IRFD210

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable

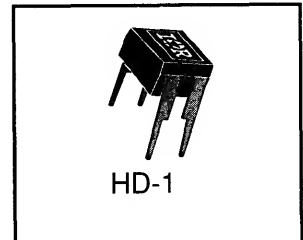


$BV_{DSS}$  200V  
 $R_{DS(on)}$  1.5 $\Omega$   
 $I_D$  0.60A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



### Absolute Maximum Ratings

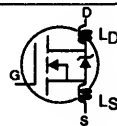
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.60	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.38	
$I_{DM}$	Pulsed Drain Current ①	4.8	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.0	W
	Linear Derating Factor	0.0083	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	79	mJ
$I_{AR}$	Avalanche Current ①	0.60	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.10	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

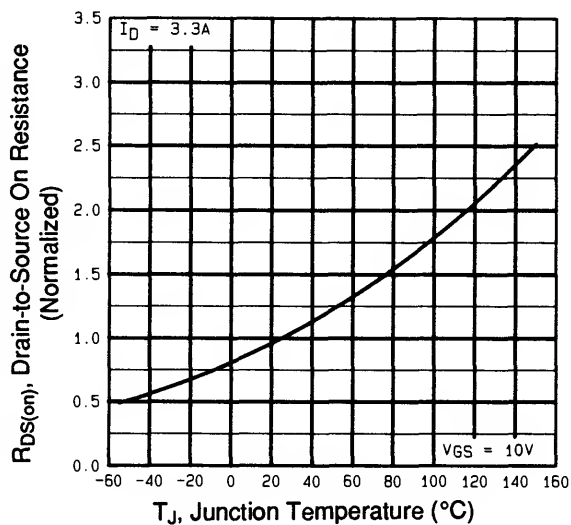
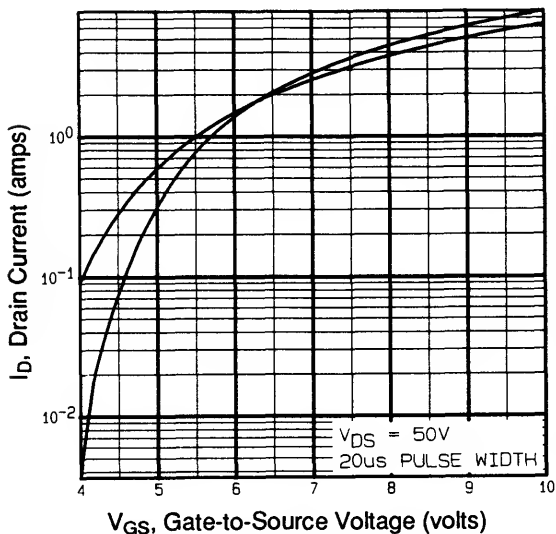
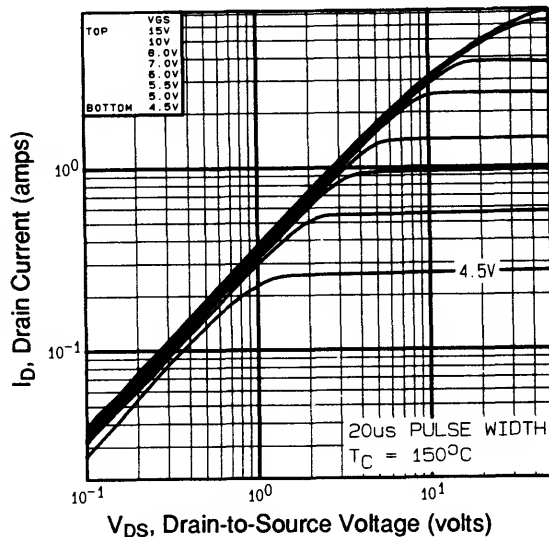
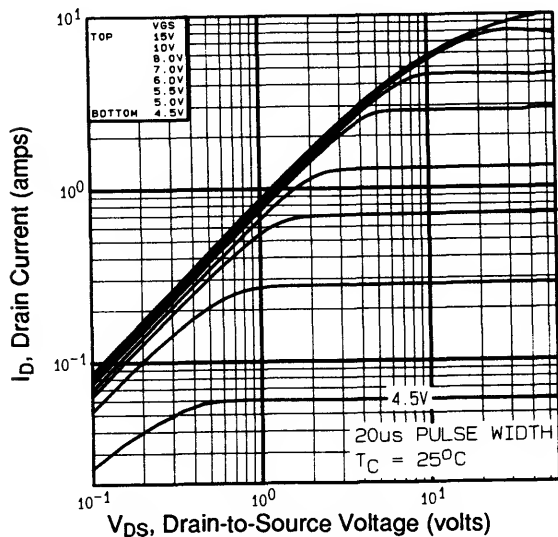
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	200	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.30	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.5	$\Omega$	$V_{GS}=10V$ , $I_D=0.36A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.10	---	---	S	$V_{DS}=50V$ , $I_{DS}=0.36A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=200V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=160V$ , $V_{GS}=0V$ , $T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	8.2	nC	$I_D=3.3A$ , $V_{DS}=160V$ , $V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	1.8		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	4.5		
$t_{d(on)}$	Turn-On Delay Time	---	8.2	---	ns	$V_{DD}=100V$ , $I_D=3.3A$ $R_G=24\Omega$ , $R_D=30\Omega$ See Fig. 10④
$t_r$	Rise Time	---	17	---		
$t_{d(off)}$	Turn-Off Delay Time	---	14	---		
$t_f$	Fall Time	---	8.9	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	140	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	53	---		
$C_{rss}$	Reverse Transfer Capacitance	---	15	---		

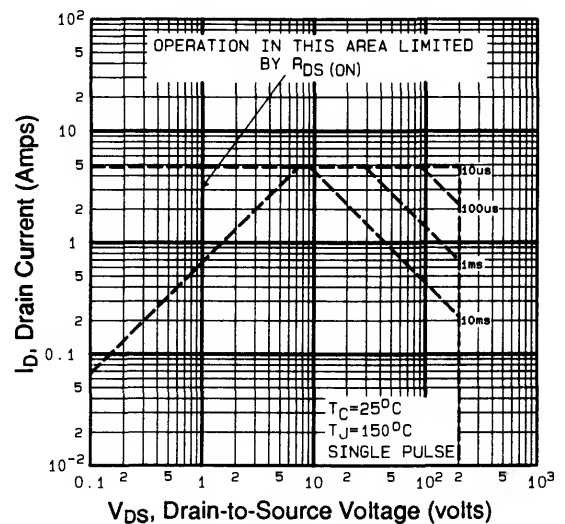
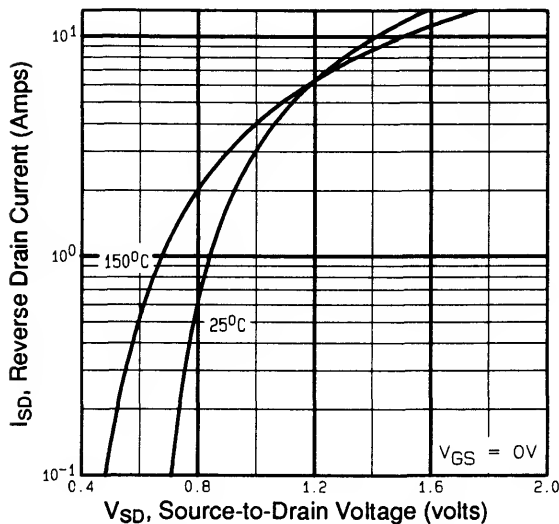
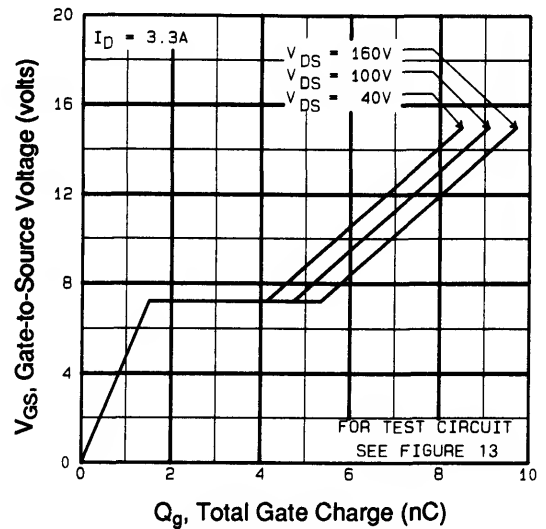
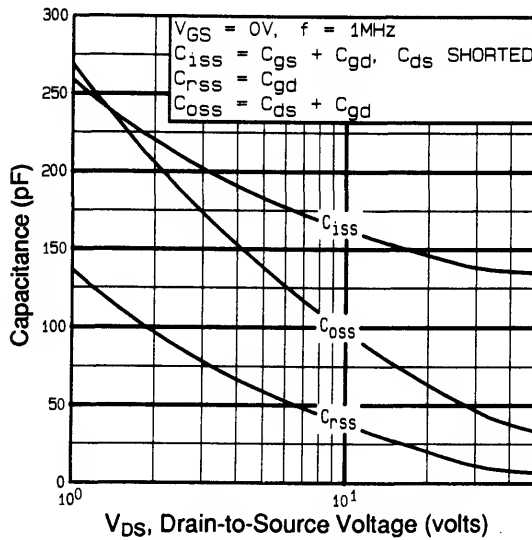

**Source-Drain Diode Ratings and Characteristics**

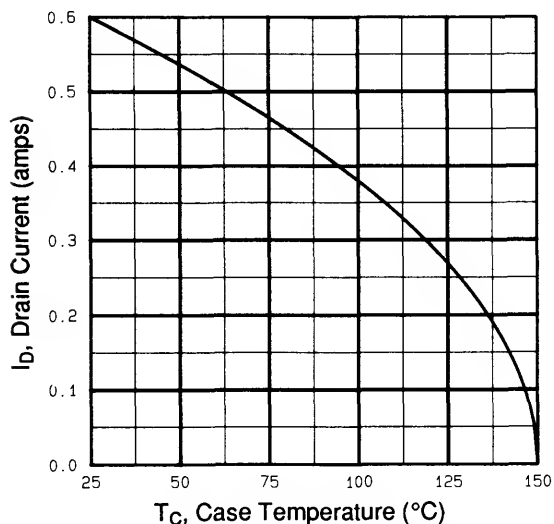
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	0.60	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	4.8		
$V_{SD}$	Diode Forward Voltage	---	---	2.0	V	$T_J=25^\circ\text{C}$ , $I_S=0.60A$ , $V_{GS}=0V$ ⑤
$t_{rr}$	Reverse Recovery Time	75	---	310	ns	$T_J=25^\circ\text{C}$ , $I_F=3.3A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.33	---	1.4	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

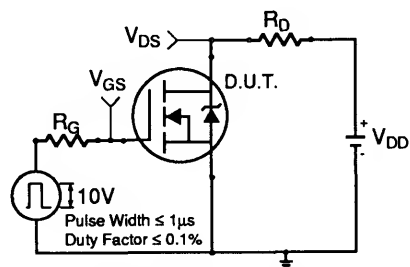
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=82\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=1.2A$  (See figure 12)
- ③  $I_{SD} \leq 3.3A$ ,  $di/dt \leq 70A/\mu s$ ,  $V_{DD} \leq BV_{DSS}$ ,  $T_J \leq 150^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$



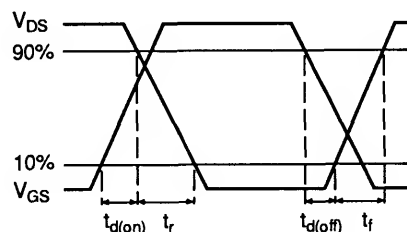




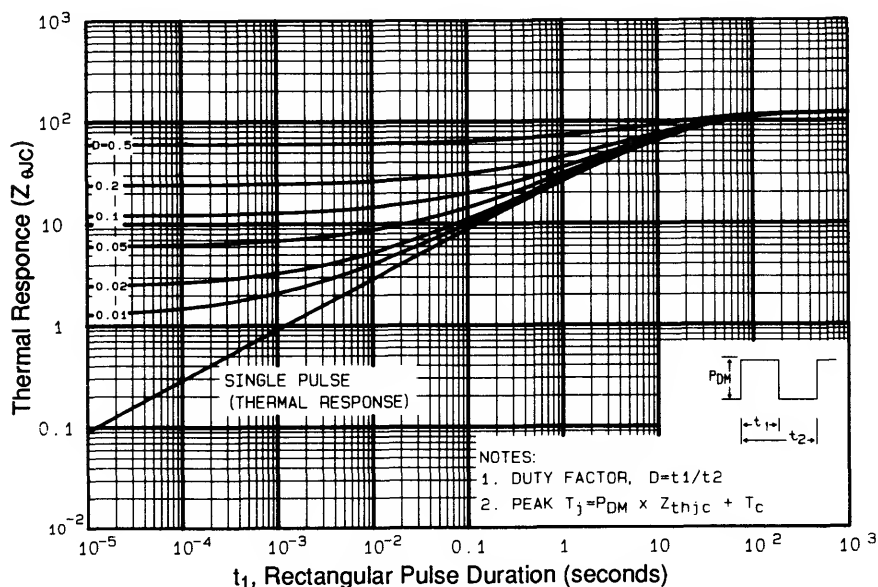
**Fig 9. Maximum Drain Current Vs. Case Temperature**



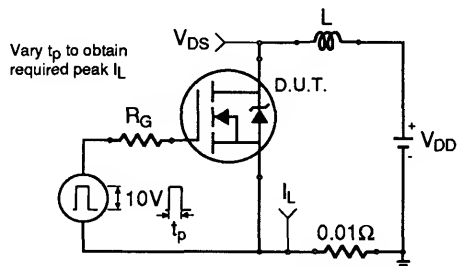
**Fig 10a. Switching Time Test Circuit**



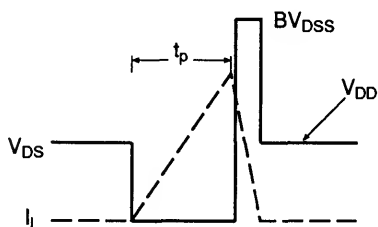
**Fig 10b. Switching Time Waveforms**



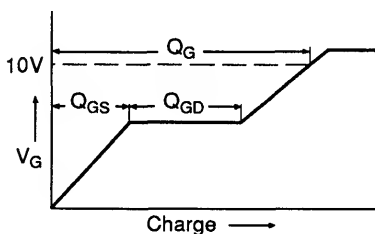
**Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case**



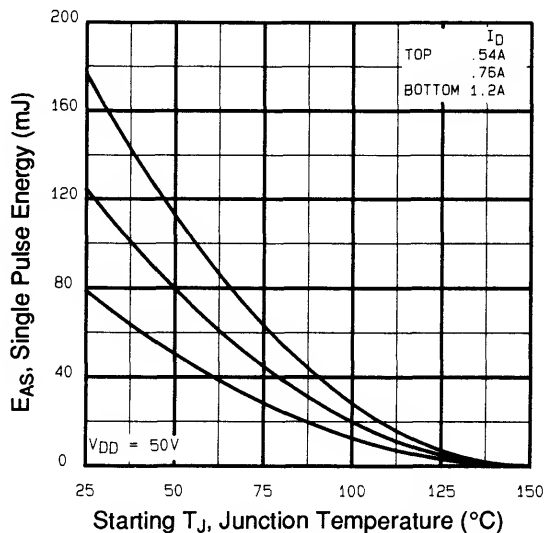
**Fig 12a.** Unclamped Inductive Test Circuit



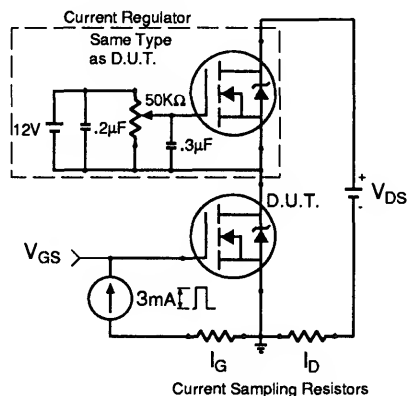
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

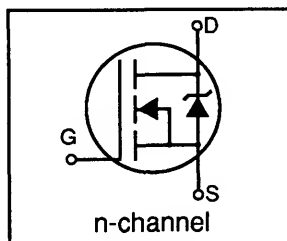
**Appendix D:** Part Marking Information

# International Rectifier

## IRFD220

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- For Automatic Insertion
- End Stackable



$BV_{DSS}$  200V  
 $R_{DS(on)}$  0.80 $\Omega$   
 $I_D$  0.80A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1

### Absolute Maximum Ratings

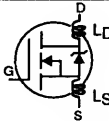
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.80	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.50	
$I_{DM}$	Pulsed Drain Current ①	6.4	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.0	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	59	mJ
$I_{AR}$	Avalanche Current ①	5.2	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.10	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

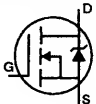
	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W④



## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	200	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.29	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.80	$\Omega$	$V_{GS}=10V$ , $I_D=0.48A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.60	---	---	S	$V_{DS}=50V$ , $I_{DS}=0.48A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=200V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=160V$ , $V_{GS}=0V$ , $T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	14	nC	$I_D=5.2A$ , $V_{DS}=160V$ , $V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.9		
$t_{d(on)}$	Turn-On Delay Time	---	7.2	---	ns	$V_{DD}=100V$ , $I_D=5.2A$ $R_G=18\Omega$ , $R_D=19\Omega$ ④
$t_r$	Rise Time	---	22	---		
$t_{d(off)}$	Turn-Off Delay Time	---	19	---		
$t_f$	Fall Time	---	13	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact. 
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	260	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	100	---		
$C_{rss}$	Reverse Transfer Capacitance	---	30	---		

## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	0.80	A	MOSFET symbol showing the integral reverse p-n junction diode. 
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	6.4		
$V_{SD}$	Diode Forward Voltage	---	---	1.8	V	$T_J=25^\circ\text{C}$ , $I_S=0.80A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	75	---	300	ns	$T_J=25^\circ\text{C}$ , $I_F=5.2A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.46	---	1.8	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

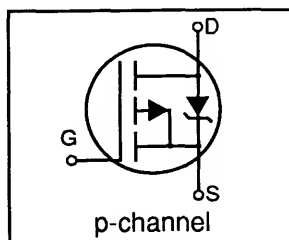
- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=36\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=1.6A$
- ③  $I_{SD}\leq 5.2A$ ,  $di/dt\leq 95A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

# International Rectifier

## IRFD9014

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- P-Channel

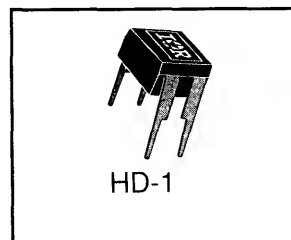


$BV_{DSS}$  -60V  
 $R_{DS(on)}$  0.50 $\Omega$   
 $I_D$  -1.1A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



### Absolute Maximum Ratings

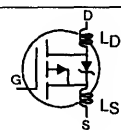
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ -10\text{V}$	-1.1	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ -10\text{V}$	-0.8	
$I_{DM}$	Pulsed Drain Current ①	-8.8	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	-1.1	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	-4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	* Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-60	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.060	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.50	$\Omega$	$V_{GS}=-10V$ , $I_D=-0.66A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	0.70	---	---	S	$V_{DS}=-25V$ , $I_{DS}=-0.66A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-60V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-48V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	12	nC	$I_D=-6.7A$ , $V_{DS}=-48V$ , $V_{GS}=-10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.8		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	5.1		
$t_{d(on)}$	Turn-On Delay Time	---	11	---	ns	$V_{DD}=-30V$ , $I_D=-6.7A$ $R_G=24\Omega$ , $R_D=4.0\Omega$ ④
$t_r$	Rise Time	---	6.3	---		
$t_{d(off)}$	Turn-Off Delay Time	---	10	---		
$t_f$	Fall Time	---	31	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	270	---	pF	$V_{GS}=0V$ , $V_{DS}=-25v$ $f=1.0Mhz$
$C_{oss}$	Output Capacitance	---	170	---		
$C_{rss}$	Reverse Transfer Capacitance	---	31	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-1.1	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-8.8		
$V_{SD}$	Diode Forward Voltage	---	---	-5.5	V	$T_J=25^\circ\text{C}$ , $I_S=-1.1A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	40	---	160	ns	$T_J=25^\circ\text{C}$ , $I_F=-6.7A$ , $di/dt=-100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.048	---	0.19	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

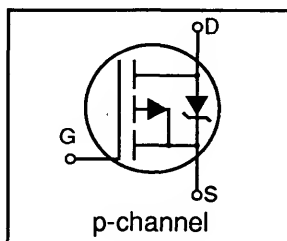
## Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature      ③  $I_{SD} \leq -6.7A$ ,  $di/dt \leq 90A/\mu s$ ,  $V_{DD} \leq BV_{DSS}$ ,  $T_J \leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$       ⑤ Mounting surface: flat, smooth, greased
- ②  $V_{DD}=-25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=51mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-2.0A$       ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$       ⑥  $K/W = ^\circ\text{C}/W$

For more information on the same die in a TO-252AA package refer to IRFR9014.

**HEXFET® Power MOSFET**

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- P-Channel



$$BV_{DSS} -60V$$

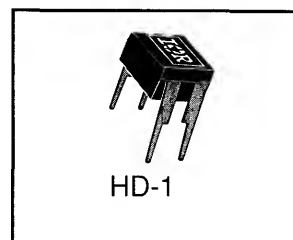
$$R_{DS(on)} 0.28\Omega$$

$$I_D -1.6A$$

**Description**

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.


**Absolute Maximum Ratings**

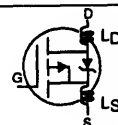
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ C$	Continuous Drain Current, $V_{GS}@-10V$	-1.6	A
$I_D @ T_C = 100^\circ C$	Continuous Drain Current, $V_{GS}@-10V$	-1.1	
$I_{DM}$	Pulsed Drain Current ①	-13	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	-1.6	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	-4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ C$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

**Thermal Resistance**

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

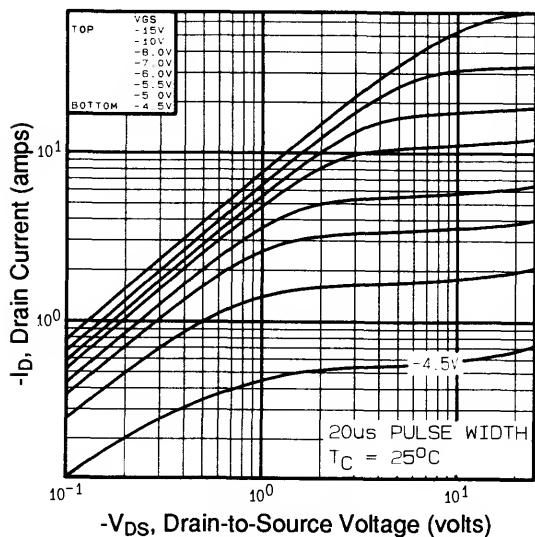
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-60	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.056	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.28	$\Omega$	$V_{GS}=-10V$ , $I_D=-0.96A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	1.3	---	---	S	$V_{DS}=-25V$ , $I_{DS}=-0.96A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-60V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-48V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	19	nC	$I_D=-11A$ , $V_{DS}=-48V$ , $V_{GS}=-10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	5.4		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	11		
$t_{d(on)}$	Turn-On Delay Time	---	13	---	ns	$V_{DD}=-30V$ , $I_D=-11A$ $R_G=18\Omega$ , $R_D=2.5\Omega$ See Fig. 10④
$t_r$	Rise Time	---	68	---		
$t_{d(off)}$	Turn-Off Delay Time	---	15	---		
$t_f$	Fall Time	---	29	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	570	---	pF	$V_{GS}=0V$ , $V_{DS}=-25v$ $f=1.0Mhz$ See Fig. 5
$C_{oss}$	Output Capacitance	---	360	---		
$C_{rss}$	Reverse Transfer Capacitance	---	65	---		


**Source-Drain Diode Ratings and Characteristics**

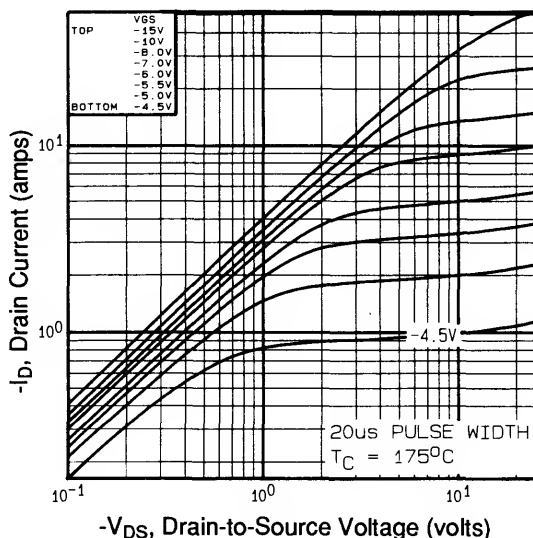
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-1.6	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-13		
$V_{SD}$	Diode Forward Voltage	---	---	-6.3	V	$T_J=25^\circ\text{C}$ , $I_S=-1.6A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	50	---	200	ns	$T_J=25^\circ\text{C}$ , $I_F=-11A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.16	---	0.64	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

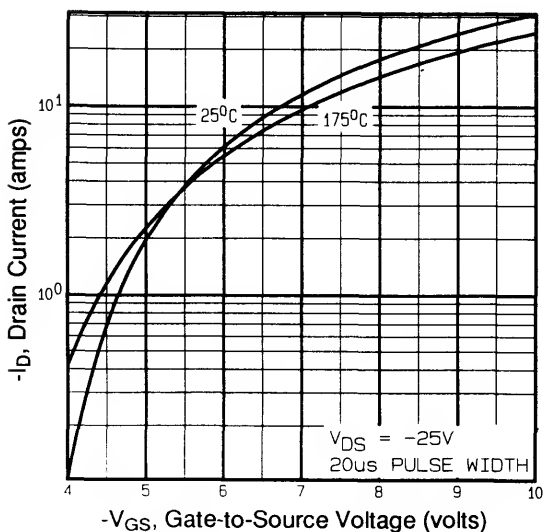
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=-25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=17mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-3.2A$
- ③  $I_{SD}\leq -11A$ ,  $di/dt\leq 140A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$



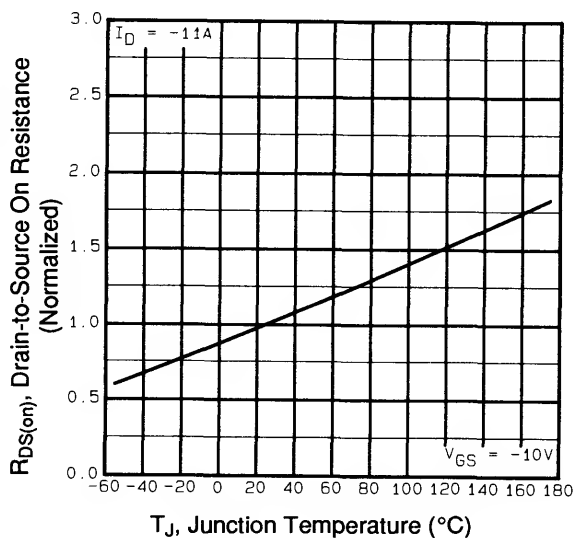
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$



**Fig 3. Typical Transfer Characteristics**



**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**

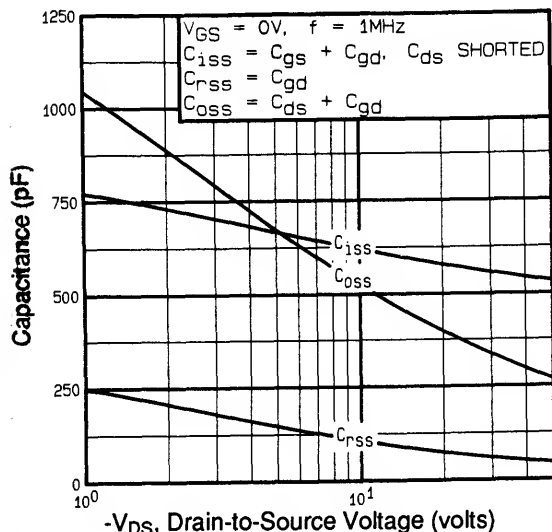


Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

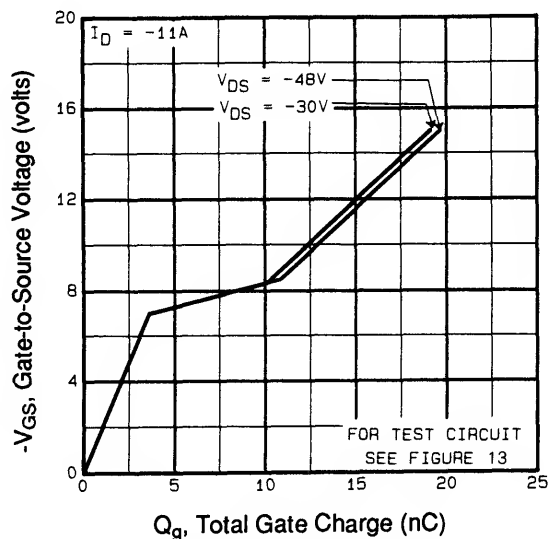


Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

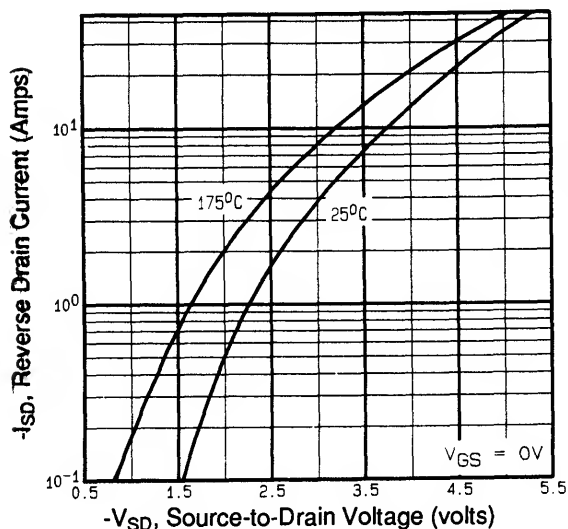


Fig 7. Typical Source-Drain Diode Forward Voltage

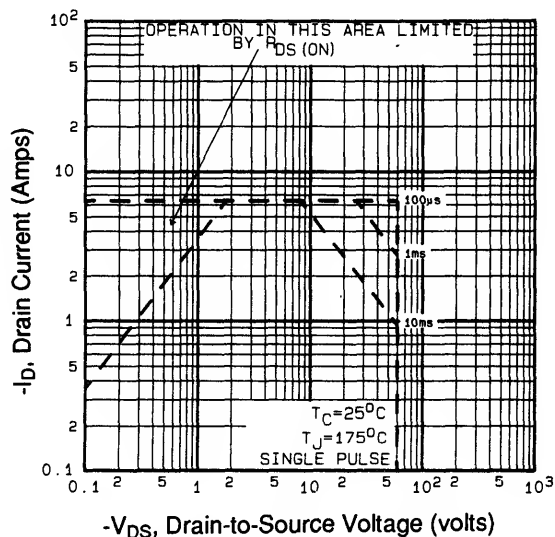
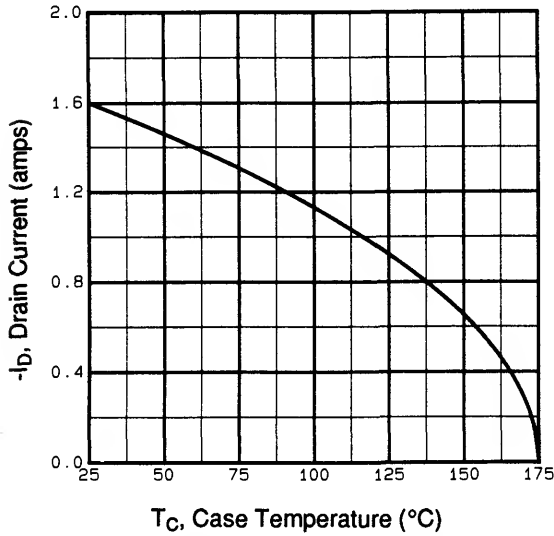
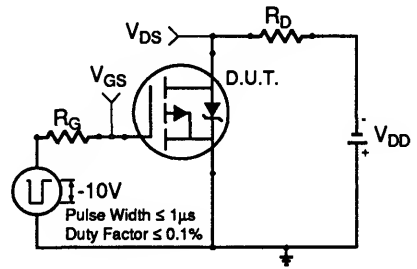


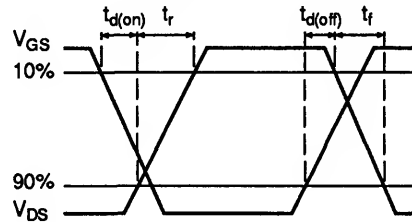
Fig 8. Maximum Safe Operating Area



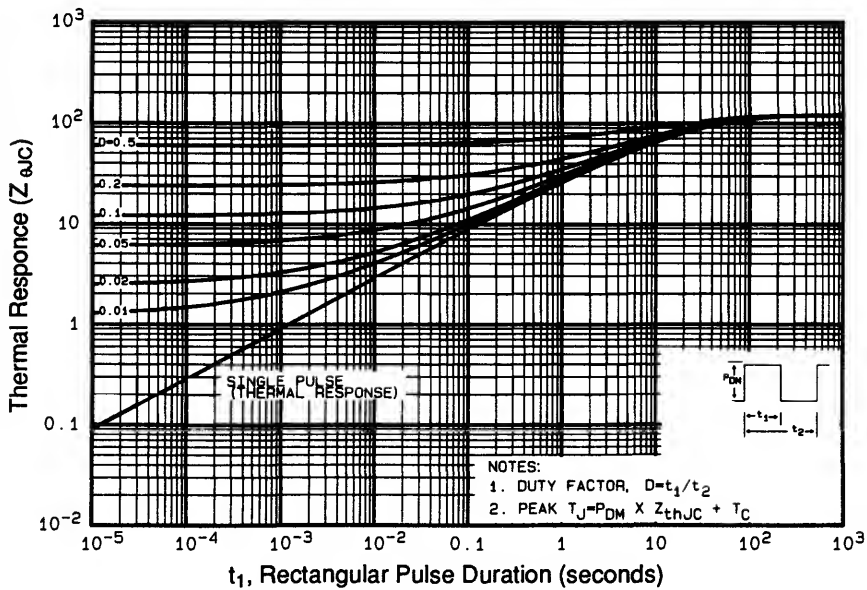
**Fig 9.** Maximum Drain Current Vs. Case Temperature



**Fig 10a.** Switching Time Test Circuit

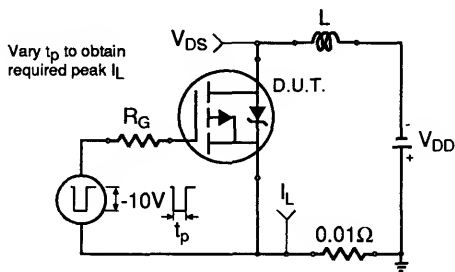


**Fig 10b.** Switching Time Waveforms

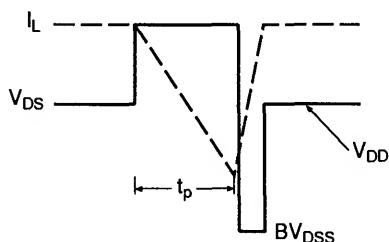


**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

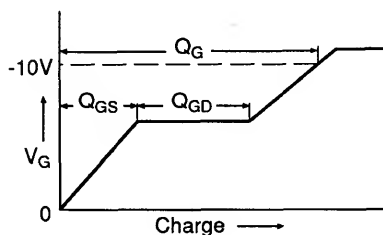




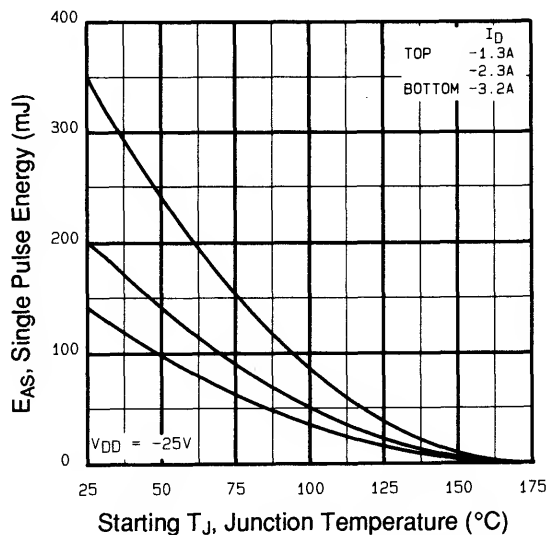
**Fig 12a.** Unclamped Inductive Test Circuit



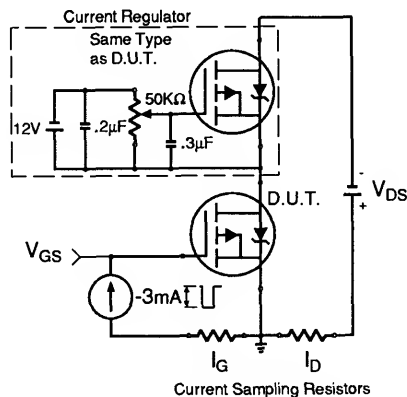
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

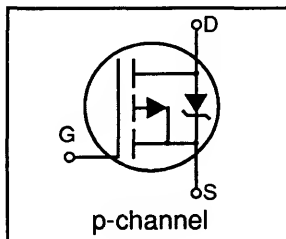
**Appendix D:** Part Marking Information

# International Rectifier

## IRFD9110

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- P-Channel



$$BV_{DSS} -100V$$

$$R_{DS(on)} 1.2\Omega$$

$$I_D -0.70A$$

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1  
Similar to M0-001AN

### Absolute Maximum Ratings

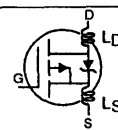
	Parameter	Max.	Units
$I_D @ T_C = 25^{\circ}C$	Continuous Drain Current, $V_{GS}@-10V$	-0.70	A
$I_D @ T_C = 100^{\circ}C$	Continuous Drain Current, $V_{GS}@-10V$	-0.49	
$I_{DM}$	Pulsed Drain Current ①	-5.6	
$P_D@ T_C = 25^{\circ}C$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	-0.70	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	-5.5	V/ns
$T_J$	Operating Junction and	-55 to +175	$^{\circ}C$
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-100	---	---	V	$V_{GS}=0\text{V}$ , $I_D=-250\mu\text{A}$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.091	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.2	$\Omega$	$V_{GS}=-10\text{V}$ , $I_D=-0.42\text{A}$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu\text{A}$
$g_{fs}$	Forward Transconductance	0.60	---	---	S	$V_{DS}=-50\text{V}$ , $I_{DS}=-0.42\text{A}$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu\text{A}$	$V_{DS}=-100\text{V}$ , $V_{GS}=0\text{V}$
		---	---	-1000		$V_{DS}=-80\text{V}$ , $V_{GS}=0\text{V}$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20\text{V}$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20\text{V}$
$Q_g$	Total Gate Charge	---	---	8.7	nC	$I_D=-4.0\text{A}$ , $V_{DS}=-80\text{V}$ , $V_{GS}=-10\text{V}$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.2		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	4.1		
$t_{d(on)}$	Turn-On Delay Time	---	10	---	ns	$V_{DD}=-50\text{V}$ , $I_D=-4.0\text{A}$ $R_G=24\Omega$ , $R_D=11\Omega$ See Fig. 10④
$t_r$	Rise Time	---	27	---		
$t_{d(off)}$	Turn-Off Delay Time	---	15	---		
$t_f$	Fall Time	---	17	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	200	---	pF	$V_{GS}=0\text{V}$ , $V_{DS}=-25\text{v}$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	94	---		
$C_{rss}$	Reverse Transfer Capacitance	---	18	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-0.70	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-5.6		
$V_{SD}$	Diode Forward Voltage	---	---	-5.5	V	$T_J=25^\circ\text{C}$ , $I_S=-0.70\text{A}$ , $V_{GS}=0\text{V}$ ④
$t_{rr}$	Reverse Recovery Time	41	---	160	ns	$T_J=25^\circ\text{C}$ , $I_F=-4.0\text{A}$ , $di/dt=100\text{A}/\mu\text{S}$ ④
$Q_{RR}$	Reverse Recovery Charge	0.075	---	0.30	$\mu\text{C}$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=-25\text{V}$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=53\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-2.0\text{A}$  (See figure 12)
- ③  $I_{SD}\leq-4.0\text{A}$ ,  $di/dt\leq 75\text{A}/\mu\text{s}$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu\text{s}$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/\text{W}$

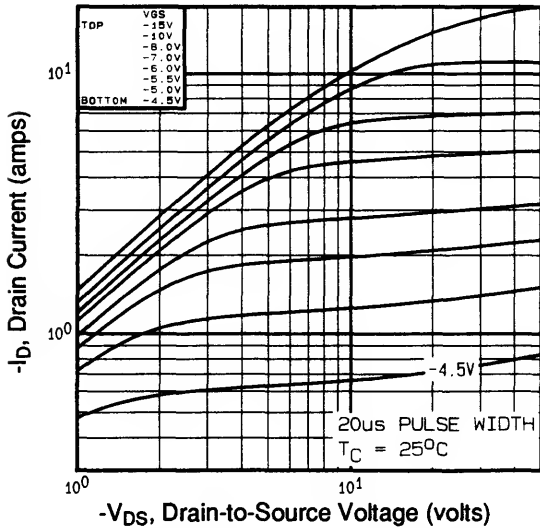


Fig 1. Typical Output Characteristics,  
 $T_C = 25^\circ\text{C}$

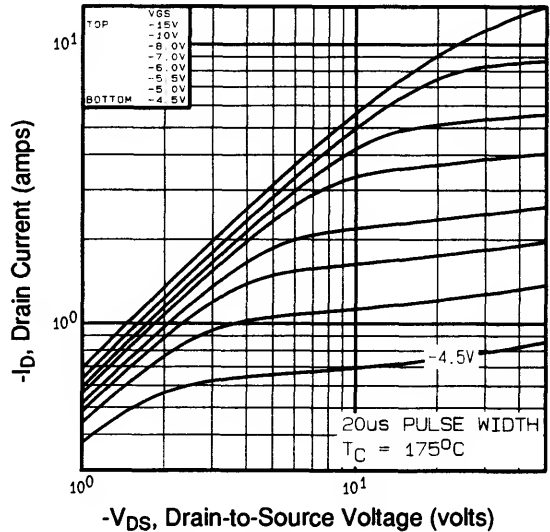


Fig 2. Typical Output Characteristics,  
 $T_C = 150^\circ\text{C}$

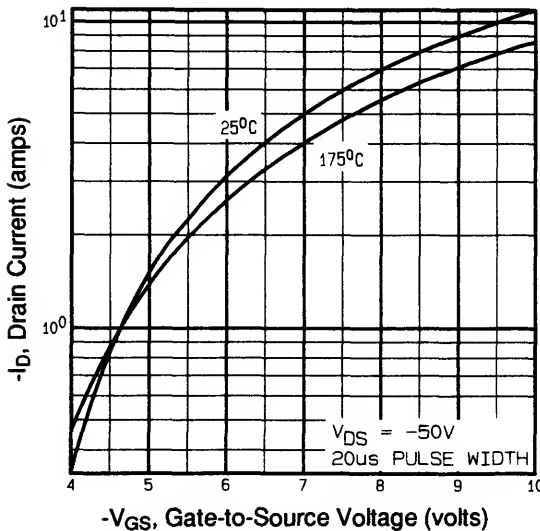


Fig 3. Typical Transfer Characteristics

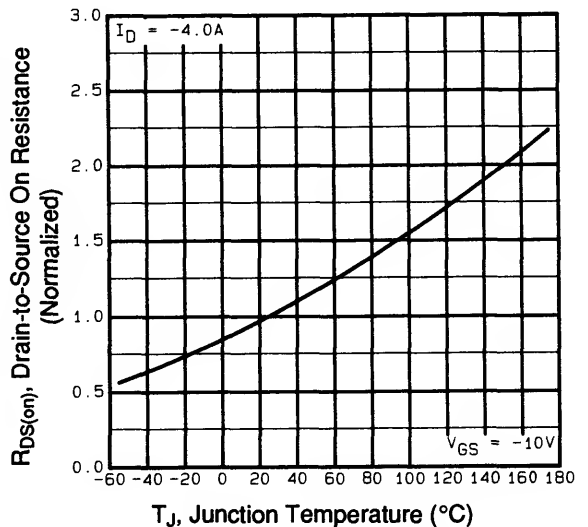
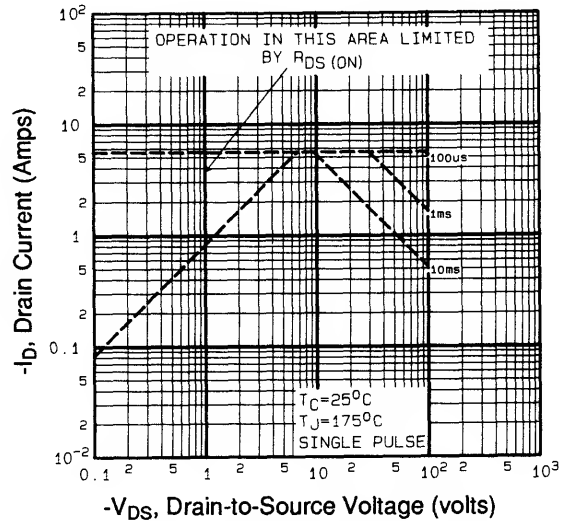
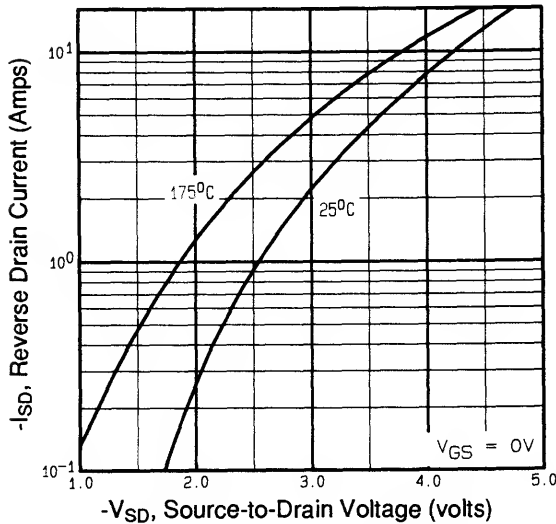
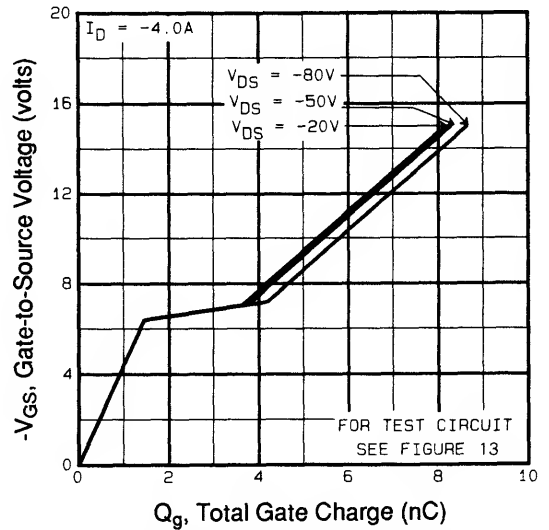
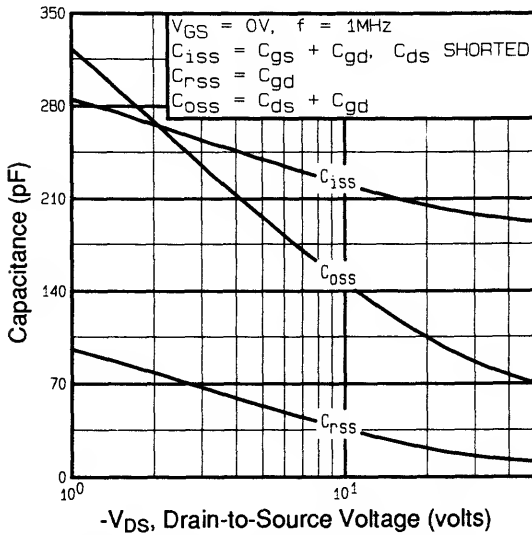
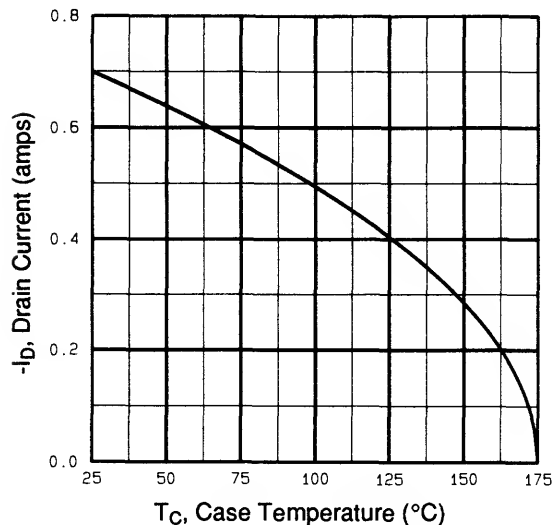
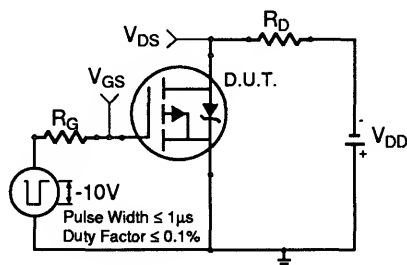


Fig 4. Normalized On-Resistance Vs.  
Temperature

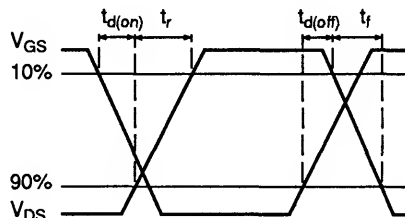




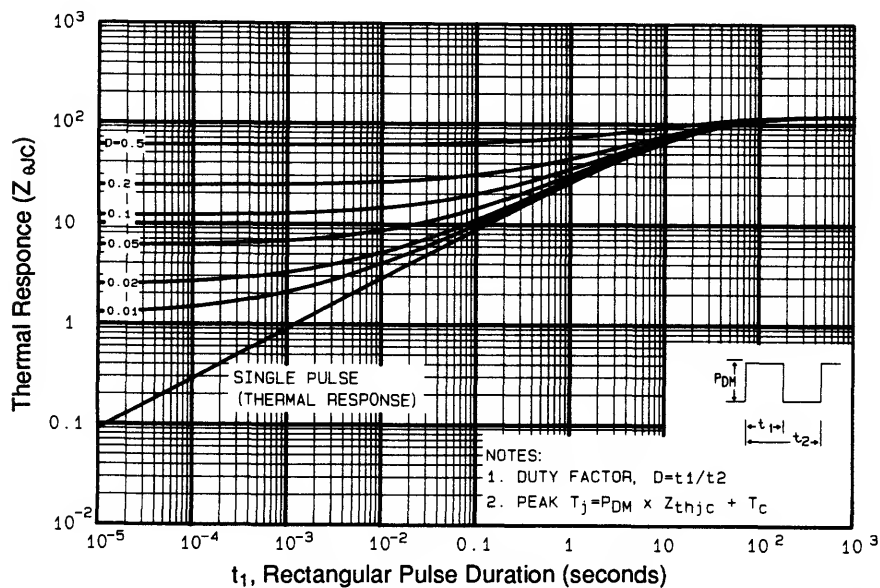
**Fig 9.** Maximum Drain Current Vs. Case Temperature



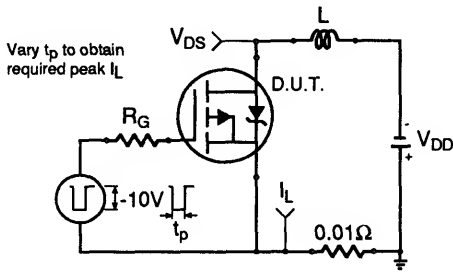
**Fig 10a.** Switching Time Test Circuit



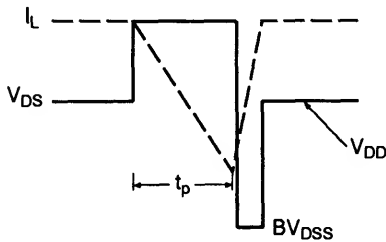
**Fig 10b.** Switching Time Waveforms



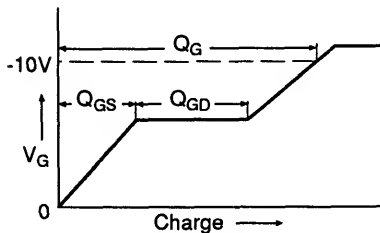
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



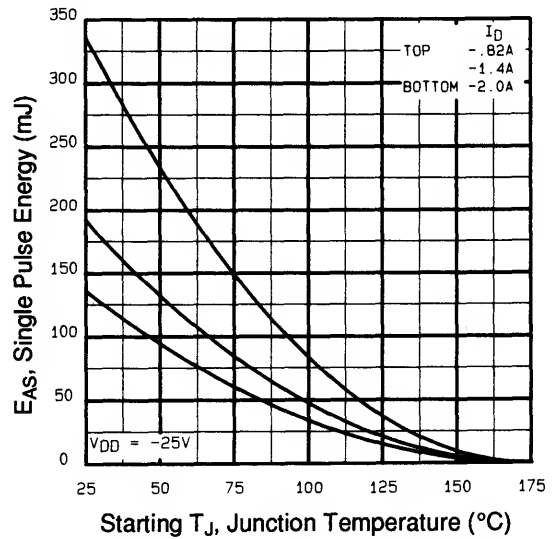
**Fig 12a.** Unclamped Inductive Test Circuit



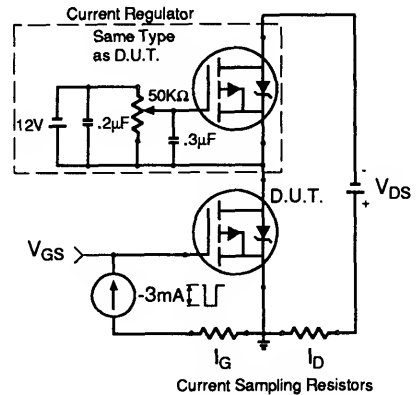
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

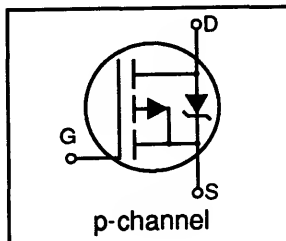
**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix D:** Part Marking Information

**HEXFET® Power MOSFET**

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- P-Channel



$$BV_{DSS} -100V$$

$$R_{DS(on)} 0.60\Omega$$

$$I_D -1.0A$$

**Description**

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.


**HD-1**
**Absolute Maximum Ratings**

	Parameter	Max.	Units
$I_D @ T_C = 25^{\circ}C$	Continuous Drain Current, $V_{GS}@-10V$	-1.0	A
$I_D @ T_C = 100^{\circ}C$	Continuous Drain Current, $V_{GS}@-10V$	-0.70	
$I_{DM}$	Pulsed Drain Current ①	-8.0	
$P_D @ T_C = 25^{\circ}C$	Maximum Power Dissipation	1.25	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	-1.0	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	-5.5	V/ns
$T_J$	Operating Junction and	-55 to +175	$^{\circ}C$
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

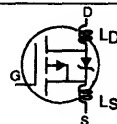
**Thermal Resistance**

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W②



Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-100	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.10	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.60	$\Omega$	$V_{GS}=-10V$ , $I_D=-0.60A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	0.71	---	---	S	$V_{DS}=-50V$ , $I_{DS}=-0.60A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-100V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	18	nC	$I_D=-6.8A$ , $V_{DS}=-80V$ , $V_{GS}=-10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	9.0		
$t_{d(on)}$	Turn-On Delay Time	---	9.6	---	ns	$V_{DD}=-50V$ , $I_D=-6.8A$ $R_G=18\Omega$ , $R_D=7.1\Omega$ See Fig. 10④
$t_r$	Rise Time	---	29	---		
$t_{d(off)}$	Turn-Off Delay Time	---	21	---		
$t_f$	Fall Time	---	25	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	390	---	pF	$V_{GS}=0V$ , $V_{DS}=-25V$ $f=1.0MHz$ See Fig. 5
$C_{oss}$	Output Capacitance	---	170	---		
$C_{rss}$	Reverse Transfer Capacitance	---	45	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-1.0	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-8.0		
$V_{SD}$	Diode Forward Voltage	---	---	-6.3	V	$T_J=25^\circ\text{C}$ , $I_S=-1.0A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	49	---	200	ns	$T_J=25^\circ\text{C}$ , $I_F=-6.8A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.17	---	0.66	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=-25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=55mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-2.0A$  (See figure 12)
- ③  $I_{SD}\leq -6.8A$ ,  $di/dt\leq 110A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ C/W$

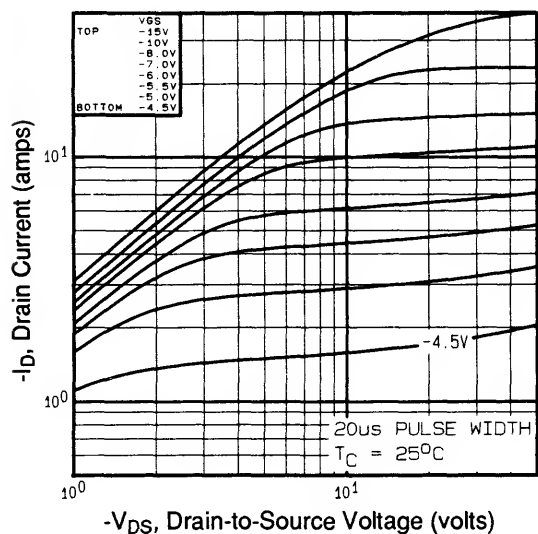


Fig 1. Typical Output Characteristics,  
 $T_C = 25^\circ\text{C}$

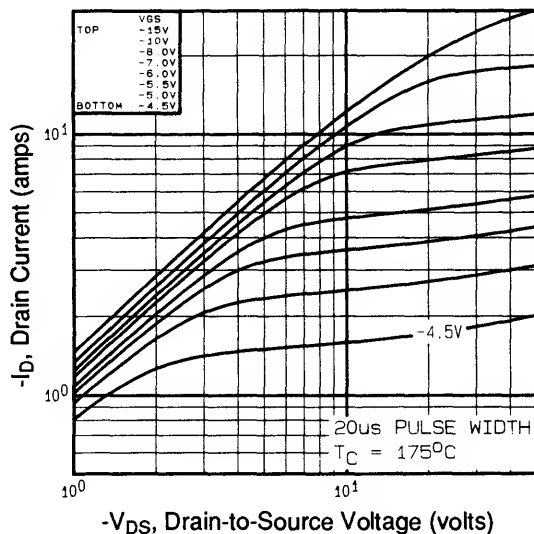


Fig 2. Typical Output Characteristics,  
 $T_C = 150^\circ\text{C}$

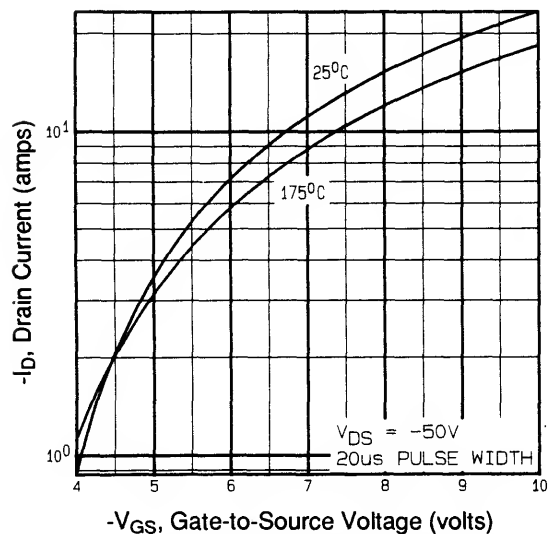


Fig 3. Typical Transfer Characteristics

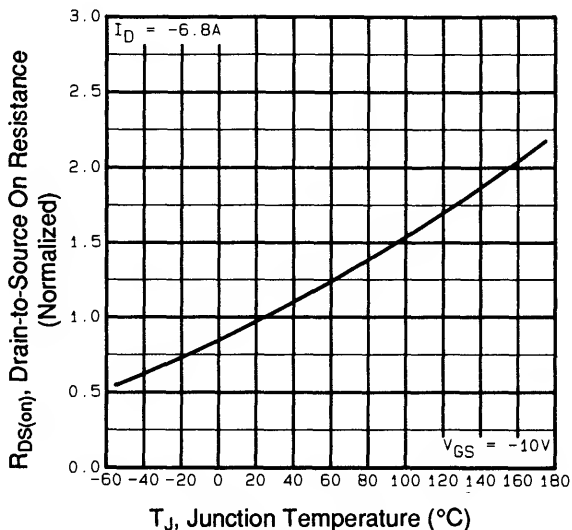
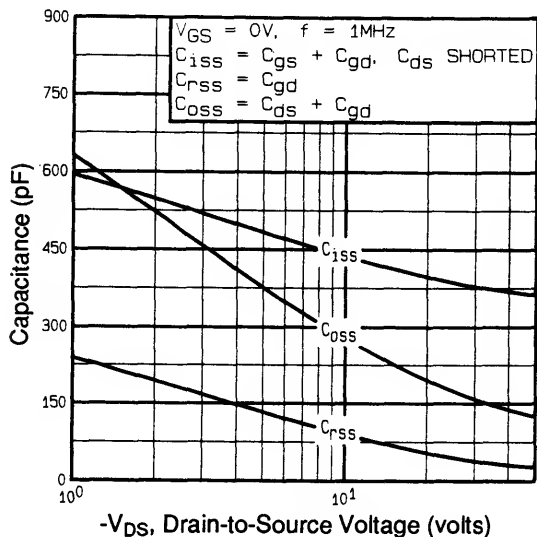
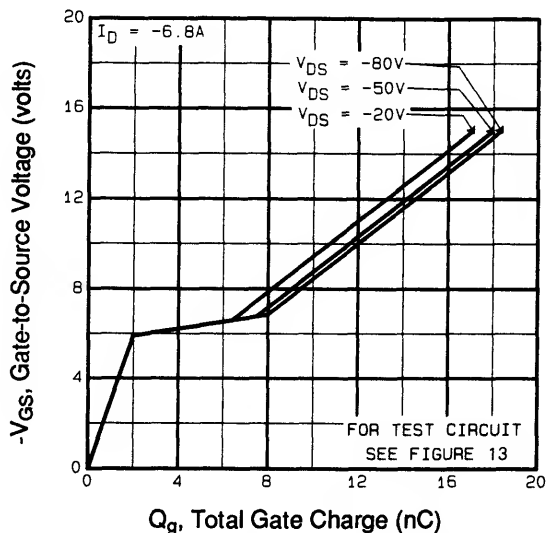


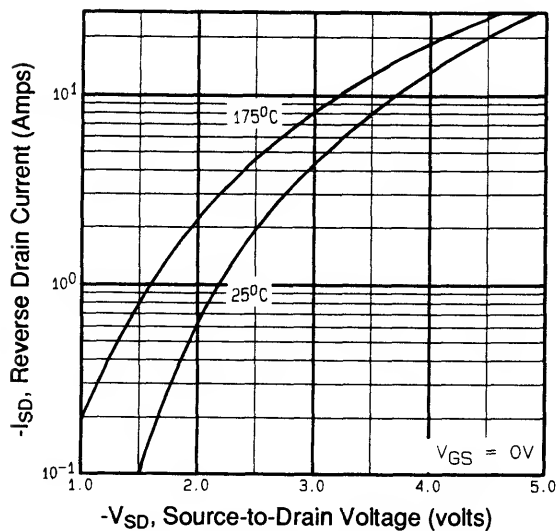
Fig 4. Normalized On-Resistance Vs.  
Temperature



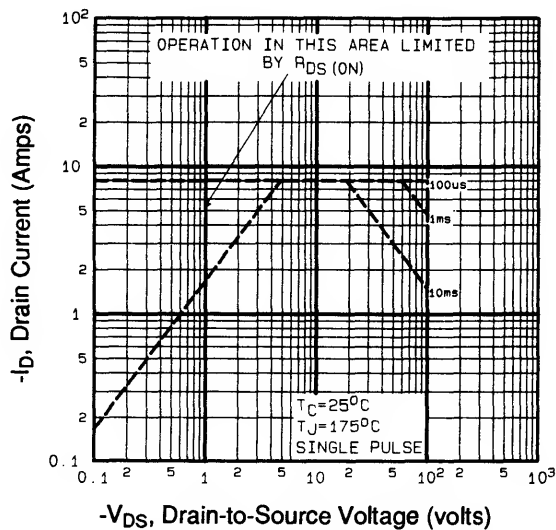
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



**Fig 7. Typical Source-Drain Diode Forward Voltage**



**Fig 8. Maximum Safe Operating Area**

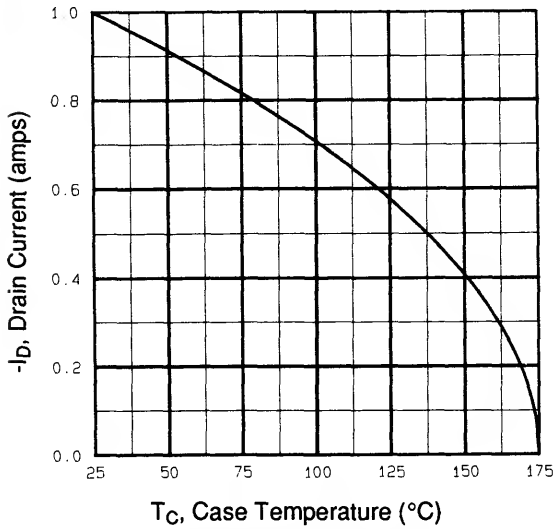


Fig 9. Maximum Drain Current Vs. Case Temperature

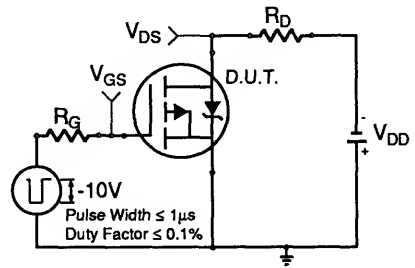


Fig 10a. Switching Time Test Circuit

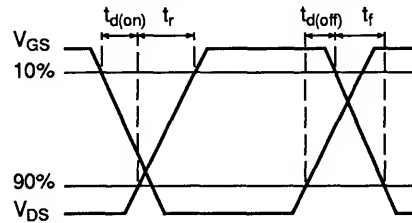


Fig 10b. Switching Time Waveforms

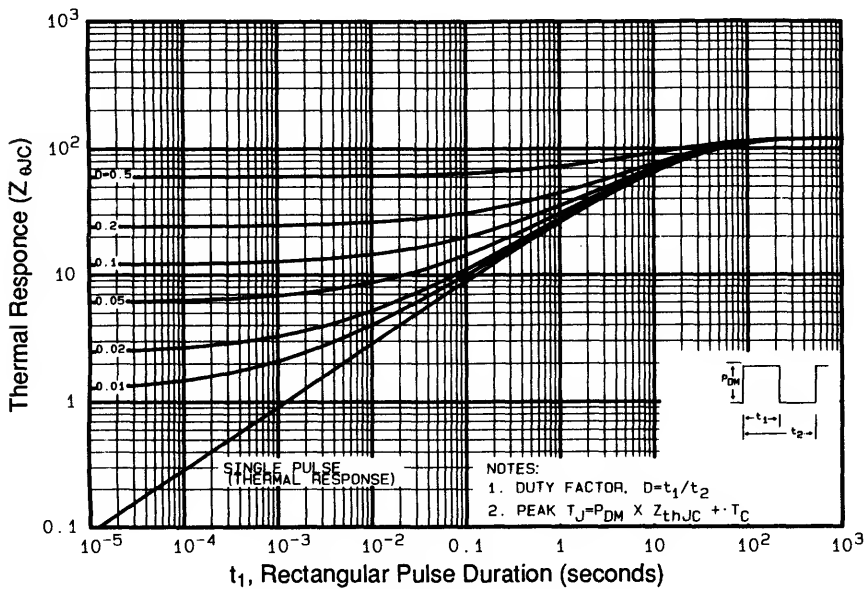
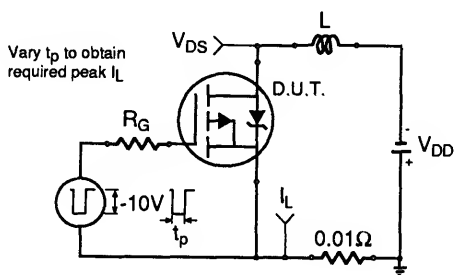
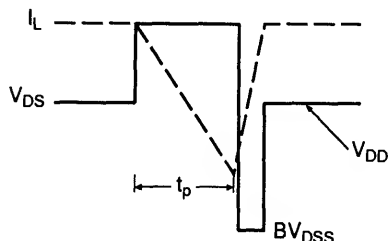


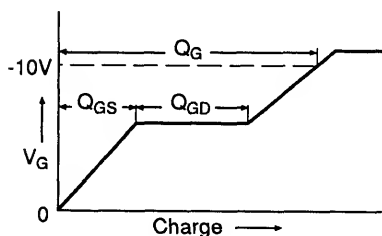
Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case



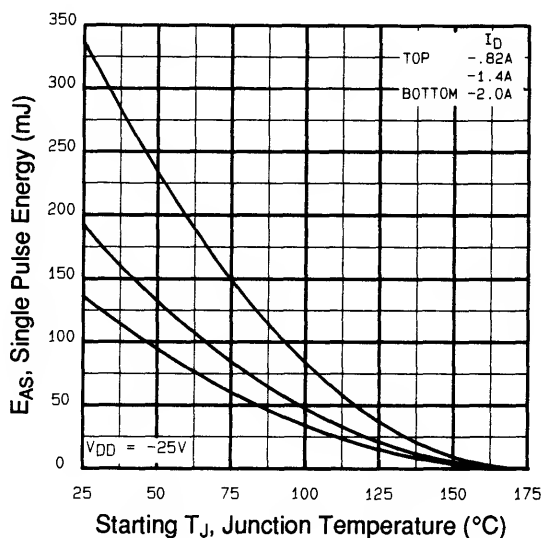
**Fig 12a.** Unclamped Inductive Test Circuit



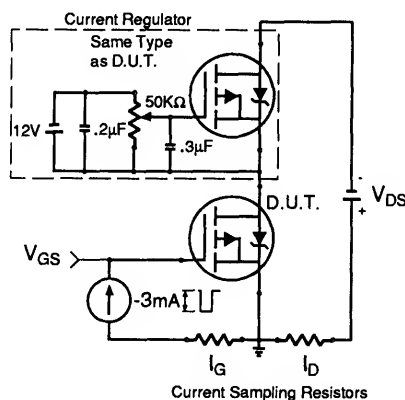
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

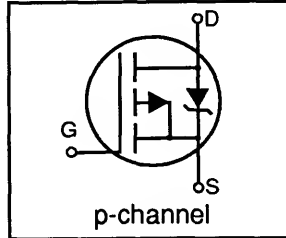
**Appendix D:** Part Marking Information

# International Rectifier

## IRFD9210

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- P-Channel

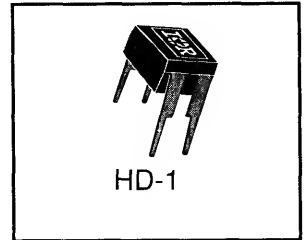


$$\begin{aligned} BV_{DSS} & -200V \\ R_{DS(on)} & 3.0\Omega \\ I_D & -0.4A \end{aligned}$$

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



### Absolute Maximum Ratings

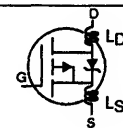
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10V$	-0.40	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10V$	-0.26	
$I_{DM}$	Pulsed Drain Current ①	-3.2	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.0	W
	Linear Derating Factor	0.0083	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	59	mJ
$I_{AR}$	Avalanche Current ①	-0.40	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.10	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	-5.0	V/ns
$T_J$	Operating Junction and	-55 to +150	$^\circ\text{C}$
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 sec.		

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-200	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	n/a	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	3.0	$\Omega$	$V_{GS}=-10V$ , $I_D=-0.24A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	n/a	---	---	S	$V_{DS}=-50V$ , $I_{DS}=-0.24A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-200V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-160V$ , $V_{GS}=0V$ , $T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	6.0	nC	$I_D=-2.4A$ , $V_{DS}=-160V$ , $V_{GS}=-10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	1.2		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	3.6		
$t_{d(on)}$	Turn-On Delay Time	---	8	---	ns	$V_{DD}=-100V$ , $I_D=-2.4A$ $R_G=24\Omega$ , $R_D=42\Omega$ ④
$t_r$	Rise Time	---	15	---		
$t_{d(off)}$	Turn-Off Delay Time	---	10	---		
$t_f$	Fall Time	---	8	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	160	---	pF	$V_{GS}=0V$ , $V_{DS}=-25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	50	---		
$C_{rss}$	Reverse Transfer Capacitance	---	12	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-0.4	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-3.2		
$V_{SD}$	Diode Forward Voltage	---	---	-5.8	V	$T_J=25^\circ\text{C}$ , $I_S=-0.4A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	n/a	---	n/a	ns	$T_J=25^\circ\text{C}$ , $I_F=-2.4A$ , $di/dt=-100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	n/a	---	n/a	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature      ③  $I_{SD} \leq 2.4A$ ,  $di/dt \leq 90A/\mu s$ ,  $V_{DD} \leq BV_{DSS}$ ,  $T_J \leq 150^\circ\text{C}$  Suggested  $R_G=24\Omega$       ⑤ Mounting surface: flat, smooth, greased
- ②  $V_{DD}=-50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=140mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-0.8A$       ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$       ⑥  $K/W = ^\circ\text{C}/W$

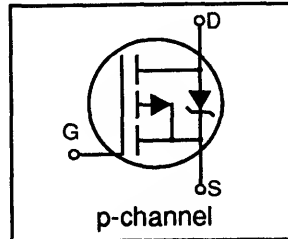
Target Data Sheet: Specification Pending; Contact Factory for Update

# International Rectifier

## IRFD9220

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- P-Channel



$BV_{DSS}$  -200V  
 $R_{DS(on)}$  1.5 $\Omega$   
 $I_D$  -0.58A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1

### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ -10\text{V}$	-0.58	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ -10\text{V}$	-0.36	
$I_{DM}$	Pulsed Drain Current ①	-4.6	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.0	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	39	mJ
$I_{AR}$	Avalanche Current ①	-0.58	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.10	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	-5.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

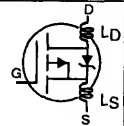
### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W④



**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-200	---	---	V	$V_{GS}=0V, I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	n/a	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.5	$\Omega$	$V_{GS}=-10V, I_D=-0.35A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}, I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	n/a	---	---	S	$V_{DS}=-25V, I_{DS}=-0.35A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-200V, V_{GS}=0V$
		---	---	-1000		$V_{DS}=-160V, V_{GS}=0V, T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	13	nC	$I_D=-4.0A, V_{DS}=-160V,$ $V_{GS}=-10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.4		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.6		
$t_{d(on)}$	Turn-On Delay Time	---	20	---	ns	$V_{DD}=-100V, I_D=-4.0A$ $R_G=18\Omega, R_D=25\Omega$ ④
$t_r$	Rise Time	---	30	---		
$t_{d(off)}$	Turn-Off Delay Time	---	25	---		
$t_f$	Fall Time	---	20	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	340	---	pF	$V_{GS}=0V, V_{DS}=-25V$ $f=1.0Mhz$
$C_{oss}$	Output Capacitance	---	105	---		
$C_{rss}$	Reverse Transfer Capacitance	---	25	---		


**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-0.58	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-4.6		
$V_{SD}$	Diode Forward Voltage	---	---	-6.3	V	$T_J=25^\circ\text{C}, I_S=-0.6A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	n/a	---	n/a	ns	$T_J=25^\circ\text{C}, I_F=-4.0A,$
$Q_{RR}$	Reverse Recovery Charge	n/a	---	n/a	$\mu C$	$di/dt=-100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=-50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=41mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-1.2A$
- ③  $I_{SD}\leq -4.0A$ ,  $di/dt\leq 90A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ C/W$

Target Data Sheet: Specification Pending; Contact Factory for Update

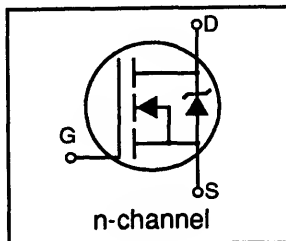
# International Rectifier

IRFR014

IRFU014

HEXFET® Power MOSFET

- Surface Mount (IRFR014)
- Straight Lead (IRFU014)
- Dynamic dv/dt Rated

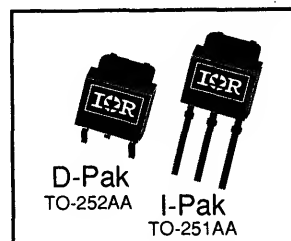


$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.20 $\Omega$   
 $I_D$  8.4A

## Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



## Absolute Maximum Ratings

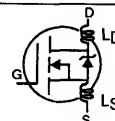
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	8.4	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	6.0	
$I_{DM}$	Pulsed Drain Current ①	34	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	30	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	47	mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.5	V/ns
$T_J$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

## Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.63	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.20	$\Omega$	$V_{GS}=10V$ , $I_D=5.0A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	2.4	---	---	S	$V_{DS}=25V$ , $I_{DS}=5.0A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=48V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	$nA$	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	11	$nC$	$I_D=10A$ , $V_{DS}=48V$ , $V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.1		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	5.8		
$t_{d(on)}$	Turn-On Delay Time	---	10	---	ns	$V_{DD}=30V$ , $I_D=10A$ $R_G=24\Omega$ , $R_D=2.7\Omega$ See Fig. 10④
$t_r$	Rise Time	---	50	---		
$t_{d(off)}$	Turn-Off Delay Time	---	13	---		
$t_f$	Fall Time	---	19	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	300	---	pF	$V_{GS}=0V$ , $V_{DS}=2$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	160	---		
$C_{rss}$	Reverse Transfer Capacitance	---	29	---		

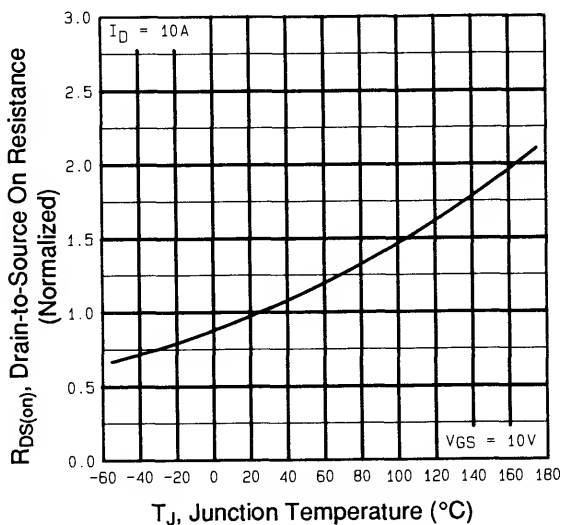
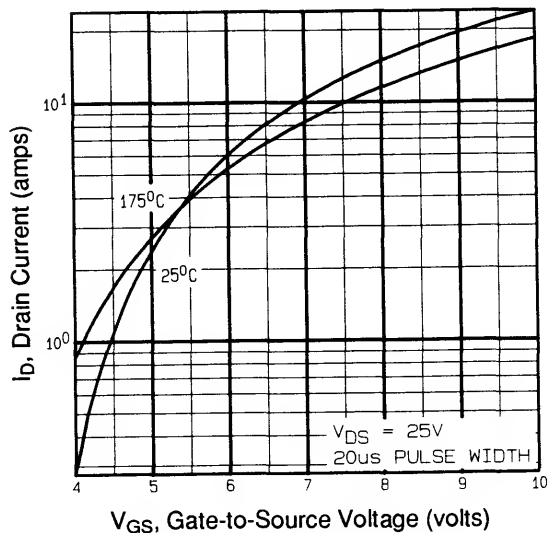
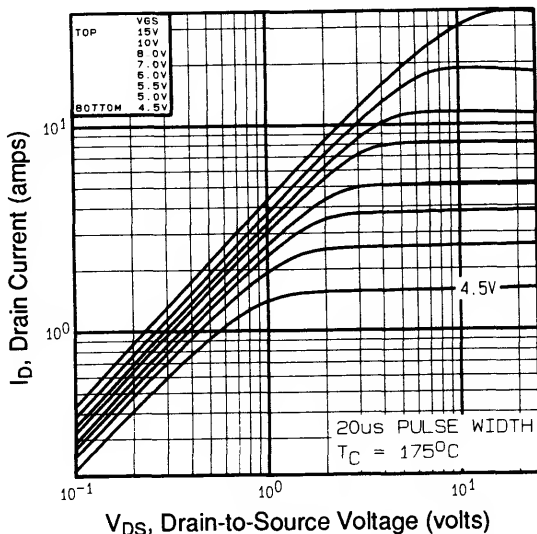
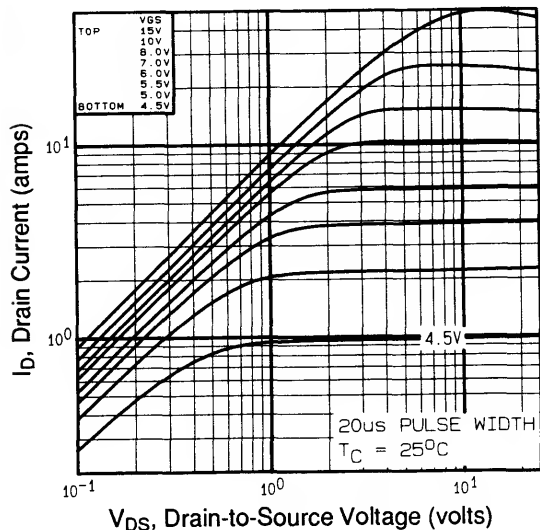


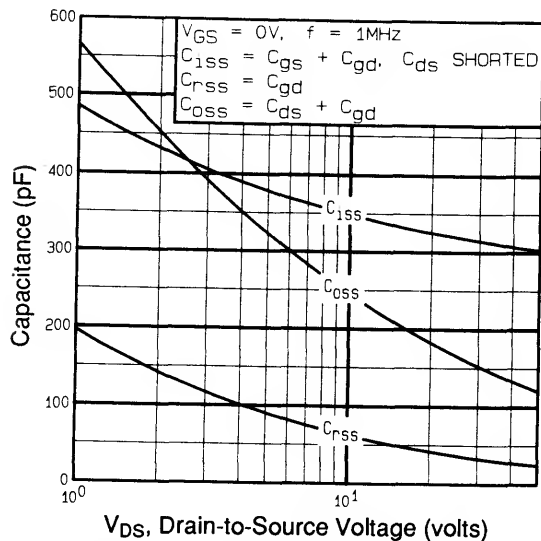
## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	8.4	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	34		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}$ , $I_S=8.4A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	34	---	140	ns	$T_J=25^\circ\text{C}$ , $I_F=10A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.090	---	0.40	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

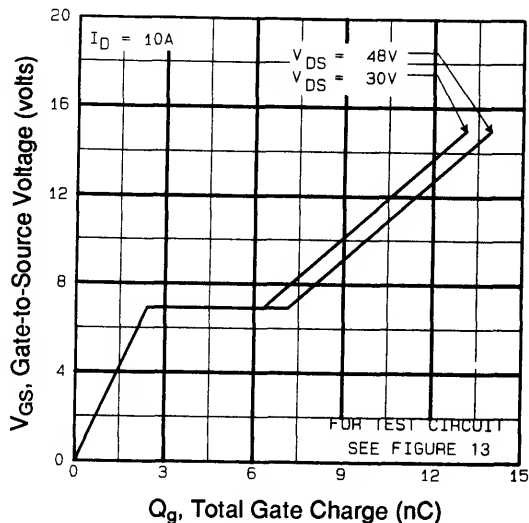
## Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=850\mu H$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=8.4A$  (See figure 12)
- ③  $I_{SD}\leq 8.4A$ ,  $di/dt\leq 90A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

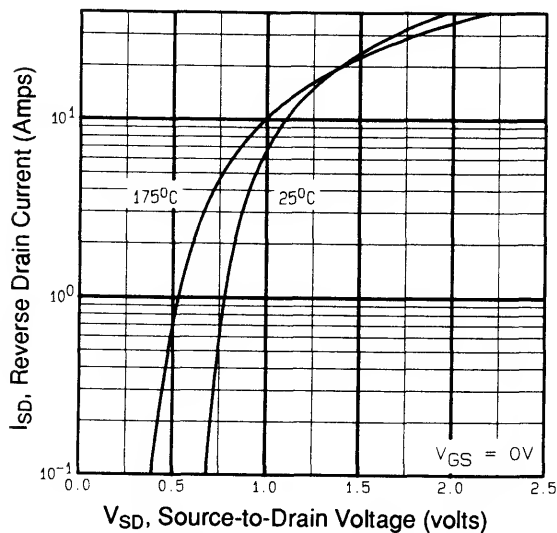




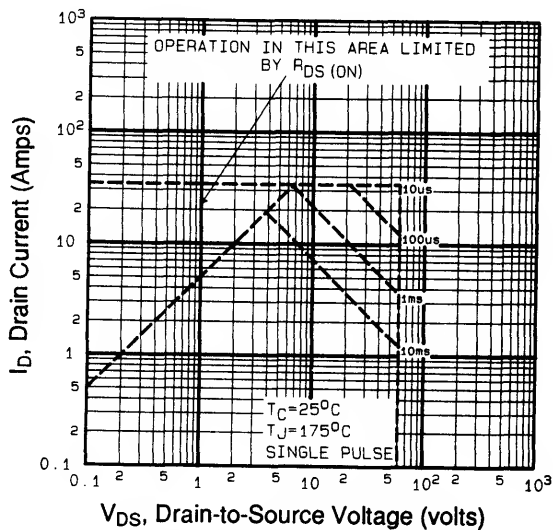
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



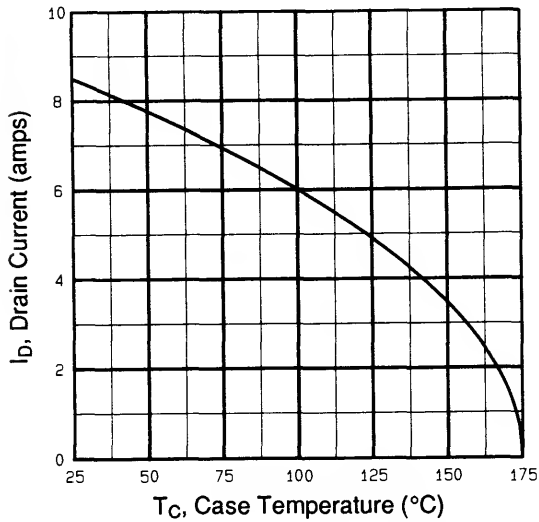
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



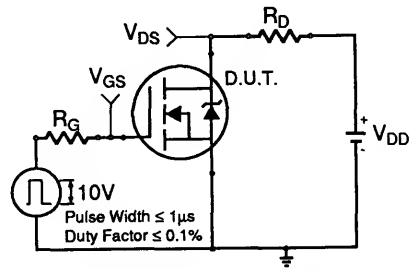
**Fig 7. Typical Source-Drain Diode Forward Voltage**



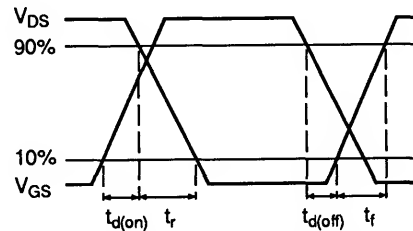
**Fig 8. Maximum Safe Operating Area**



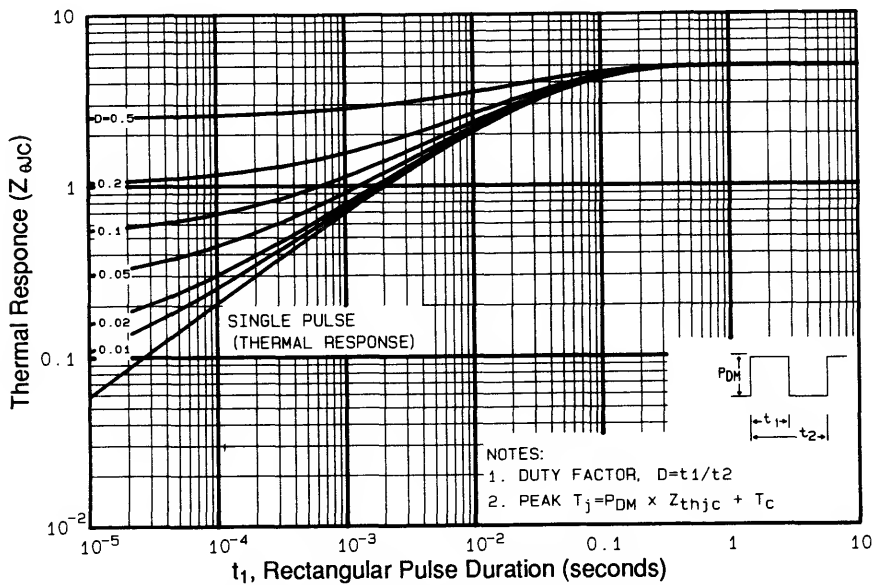
**Fig 9. Maximum Drain Current Vs. Case Temperature**



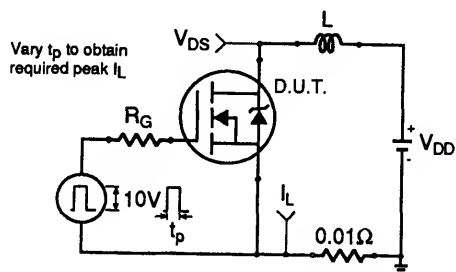
**Fig 10a. Switching Time Test Circuit**



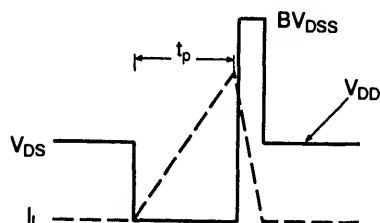
**Fig 10b. Switching Time Waveforms**



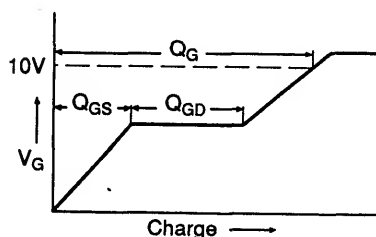
**Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case**



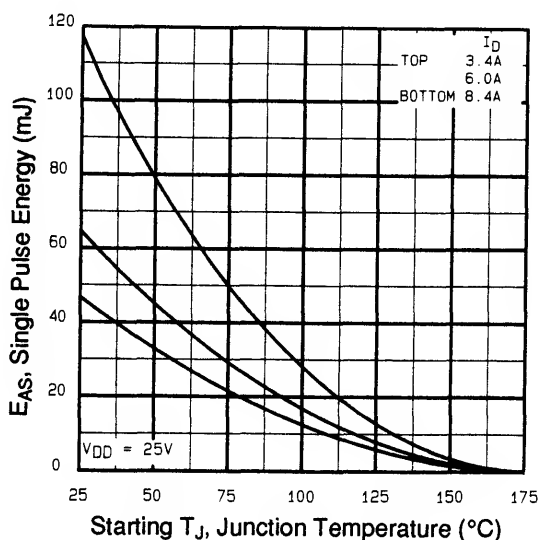
**Fig 12a.** Unclamped Inductive Test Circuit



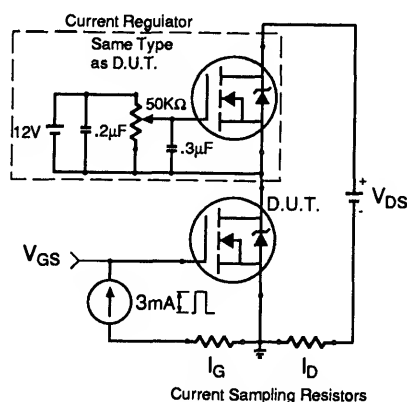
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

**Appendix D:** Part Marking Information

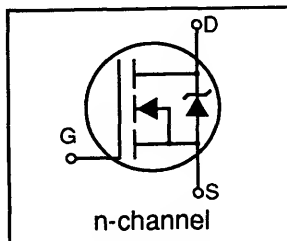
# International Rectifier

HEXFET® Power MOSFET

## IRFR024

## IRFU024

- Surface Mount (IRFR024)
- Straight Lead (IRFU024)
- Dynamic dv/dt Rated

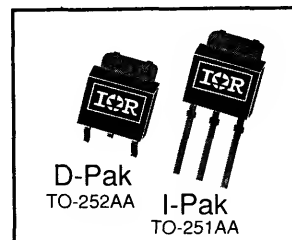


$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.10 $\Omega$   
 $I_D$  16A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	16	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	11	
$I_{DM}$	Pulsed Drain Current ①	64	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	50	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	91	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.5	V/ns
$T_J$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

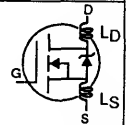
### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	



## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.061	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.10	$\Omega$	$V_{GS}=10V, I_D=9.6A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	6.2	---	---	S	$V_{DS}=25V, I_{DS}=9.6A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V, V_{GS}=0V$
		---	---	1000		$V_{DS}=48V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	28	nC	$I_D=14A, V_{DS}=48V, V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	5.4		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	13		
$t_{d(on)}$	Turn-On Delay Time	---	8.6	---	ns	$V_{DD}=30V, I_D=14A$ $R_G=18\Omega, R_D=2.0\Omega$ See Fig. 10④
$t_r$	Rise Time	---	47	---		
$t_{d(off)}$	Turn-Off Delay Time	---	27	---		
$t_f$	Fall Time	---	37	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	640	---	pF	$V_{GS}=0V, V_{DS}=2V$ (See figure 12) $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	360	---		
$C_{rss}$	Reverse Transfer Capacitance	---	79	---		

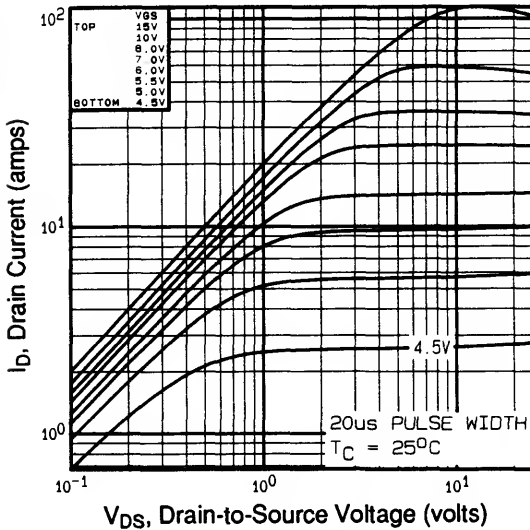


## Source-Drain Diode Ratings and Characteristics

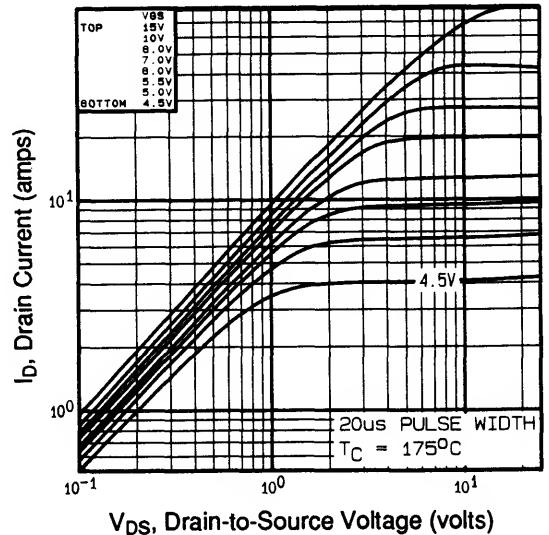
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	16	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	64		
$V_{SD}$	Diode Forward Voltage	---	---	1.5	V	$T_J=25^\circ\text{C}, I_S=16A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	49	---	200	ns	$T_J=25^\circ\text{C}, I_F=14A,$
$Q_{RR}$	Reverse Recovery Charge	0.22	---	0.88	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

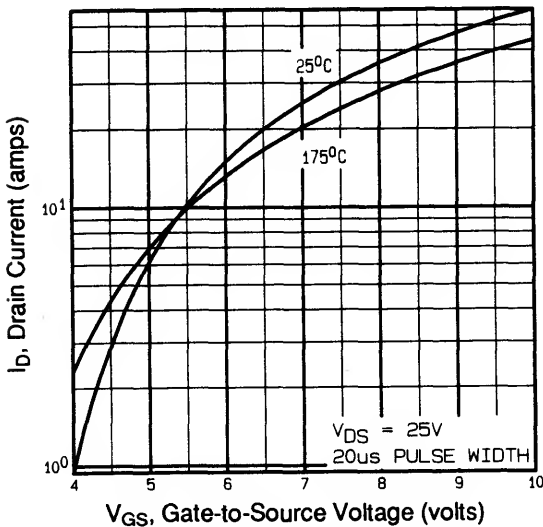
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=450\mu H$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=16A$  (See figure 12)
- ③  $I_{SD}\leq 16A$ ,  $di/dt\leq 110A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ C/W$



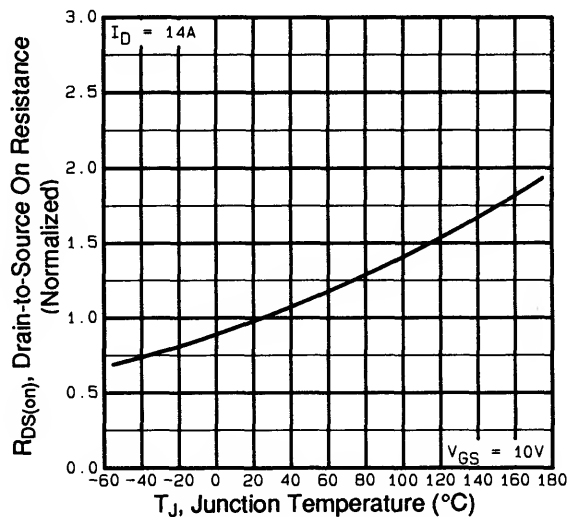
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



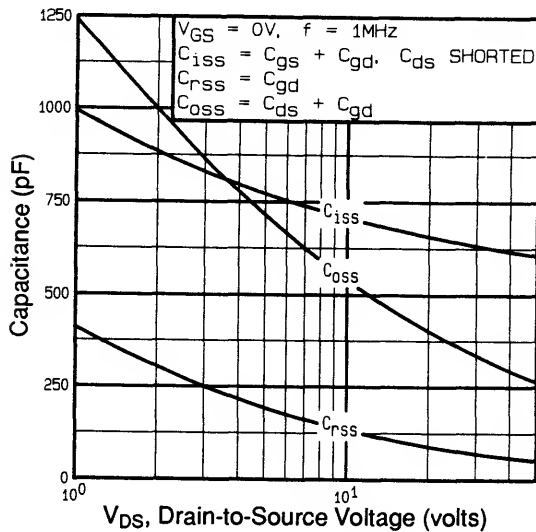
**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$



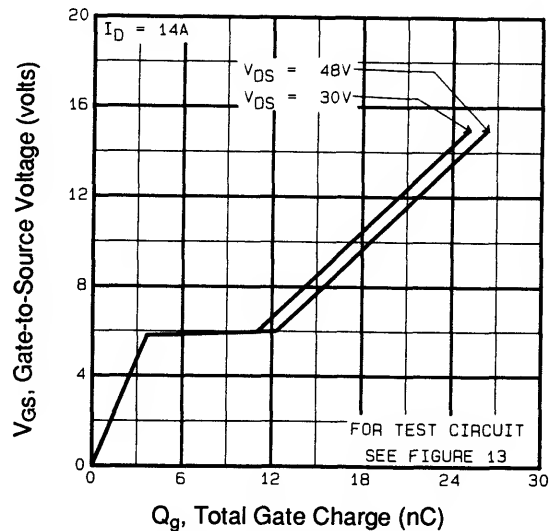
**Fig 3. Typical Transfer Characteristics**



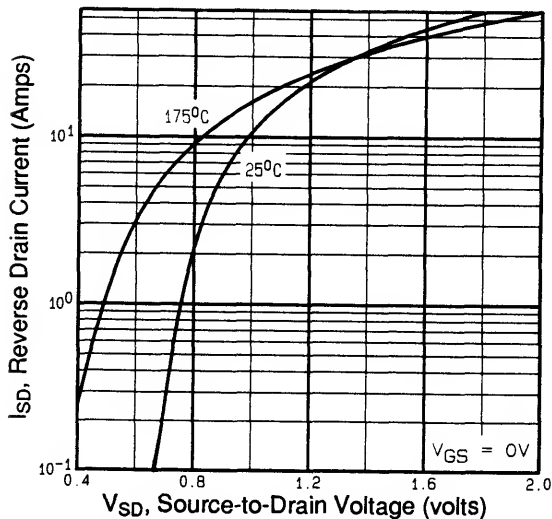
**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**



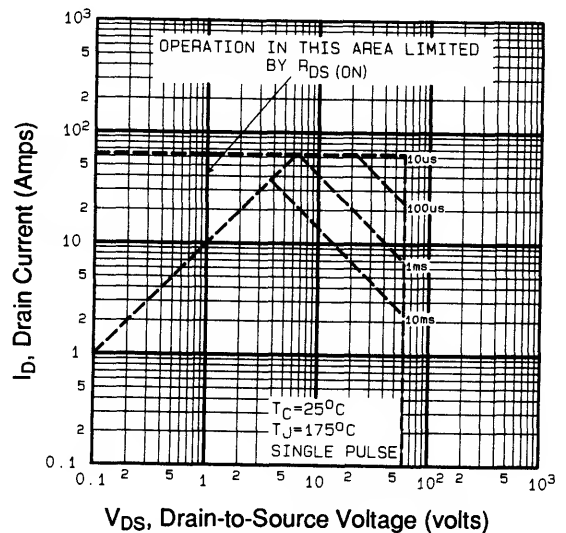
**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



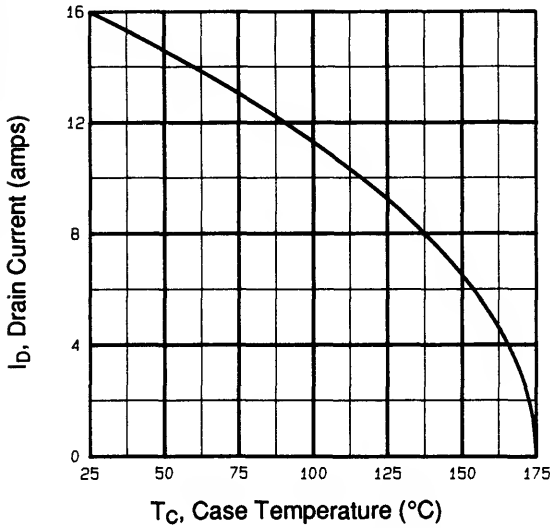
**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



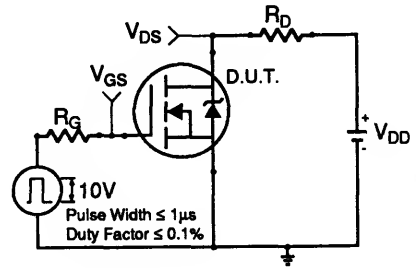
**Fig 7.** Typical Source-Drain Diode Forward Voltage



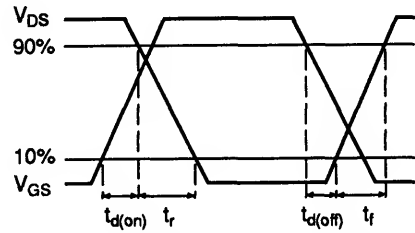
**Fig 8.** Maximum Safe Operating Area



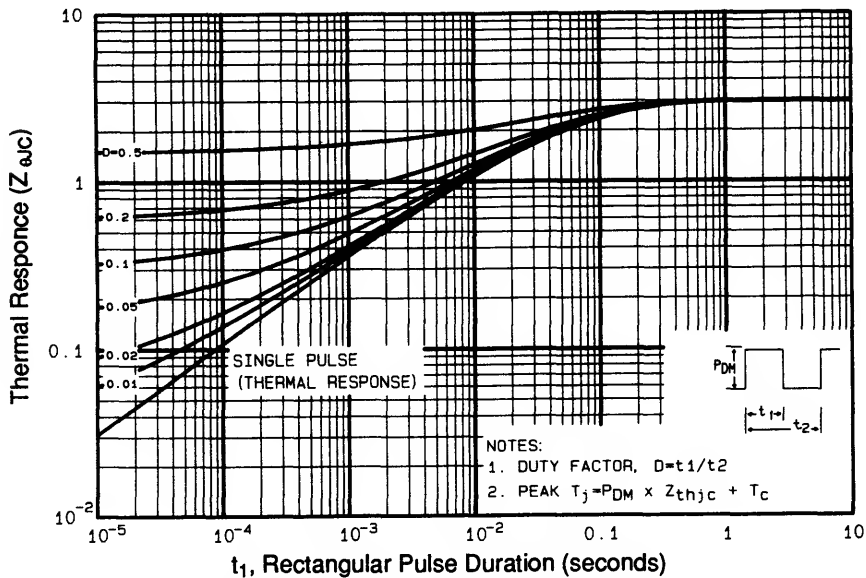
**Fig 9.** Maximum Drain Current Vs. Case Temperature



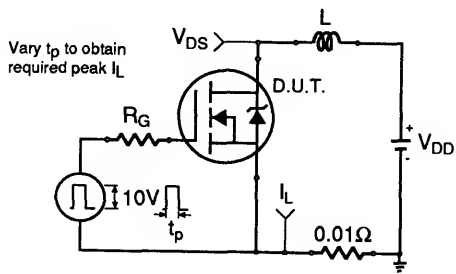
**Fig 10a.** Switching Time Test Circuit



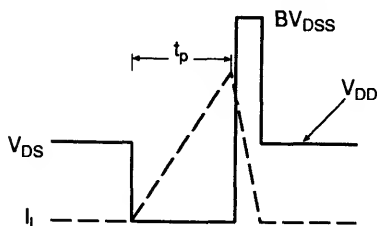
**Fig 10b.** Switching Time Waveforms



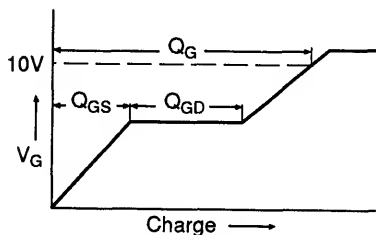
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



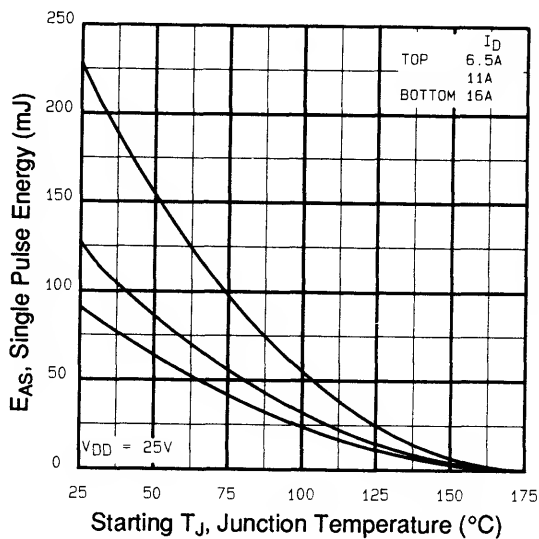
**Fig 12a.** Unclamped Inductive Test Circuit



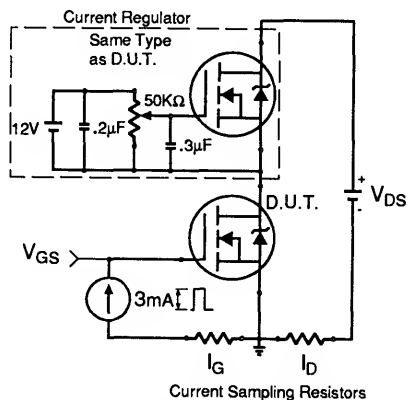
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

**Appendix D:** Part Marking Information

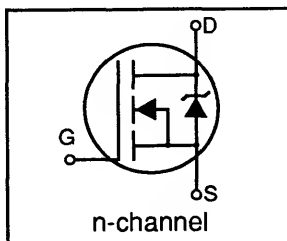
# International Rectifier

HEXFET® Power MOSFET

## IRFR110

## IRFU110

- Surface Mount (IRFR110)
- Straight Lead (IRFU110)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

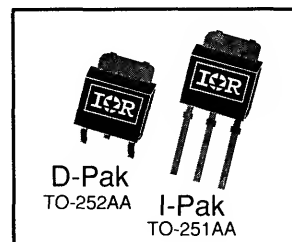


$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.54 $\Omega$   
 $I_D$  4.7A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

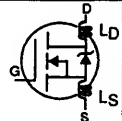
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	4.7	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	3.3	
$I_{DM}$	Pulsed Drain Current ①	19	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	30	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	100	mJ
$I_{AR}$	Avalanche Current ①	4.7	A
$E_{AR}$	Repetitive Avalanche Energy ①	3.0	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.54	$\Omega$	$V_{GS}=10V$ , $I_D=2.8A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.6	---	---	S	$V_{DS}=50V$ , $I_{DS}=2.8A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	8.3	nC	$I_D=5.6A$ , $V_{DS}=80V$ , $V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.3		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	3.8		
$t_{d(on)}$	Turn-On Delay Time	---	6.9	---	ns	$V_{DD}=50V$ , $I_D=5.6A$ $R_G=24\Omega$ , $R_D=8.4\Omega$ See Fig. 10④
$t_r$	Rise Time	---	16	---		
$t_{d(off)}$	Turn-Off Delay Time	---	15	---		
$t_f$	Fall Time	---	9.4	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	180	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	80	---		
$C_{rss}$	Reverse Transfer Capacitance	---	15	---		

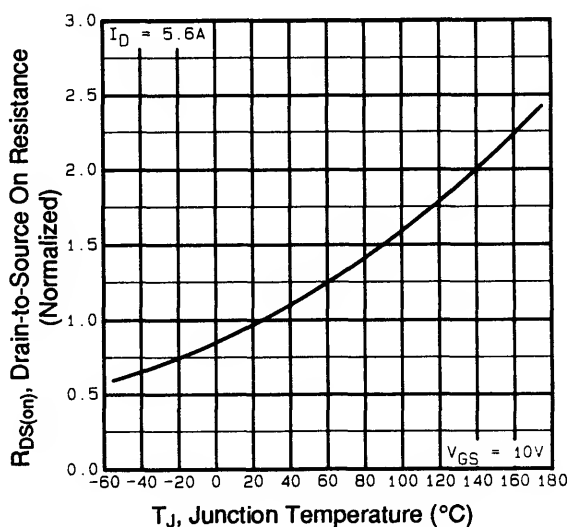
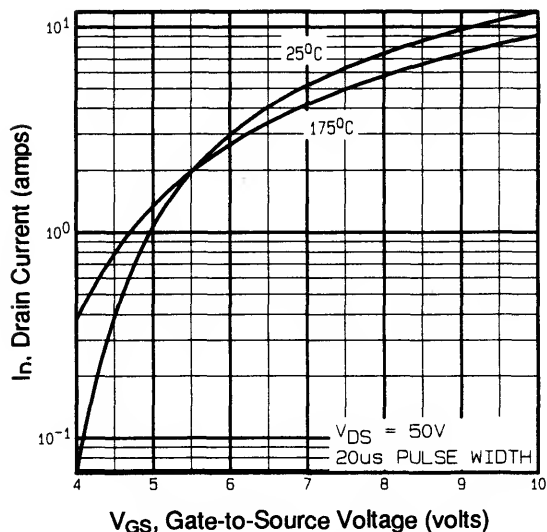
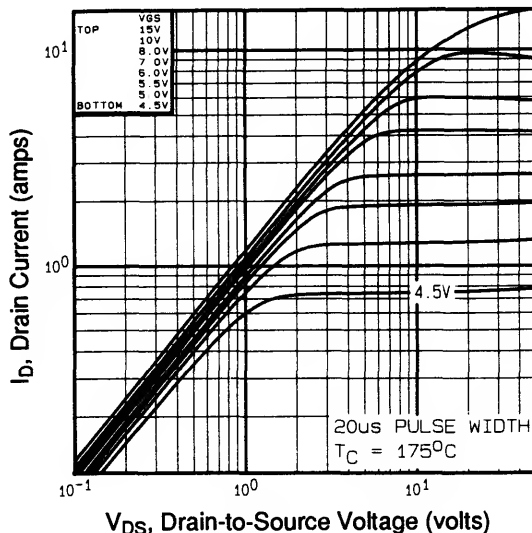
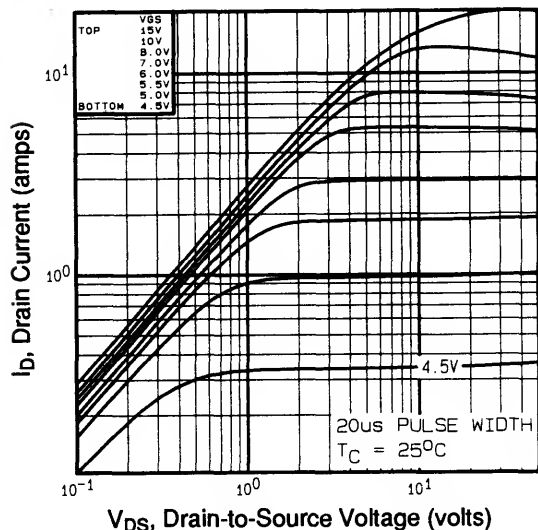


## Source-Drain Diode Ratings and Characteristics

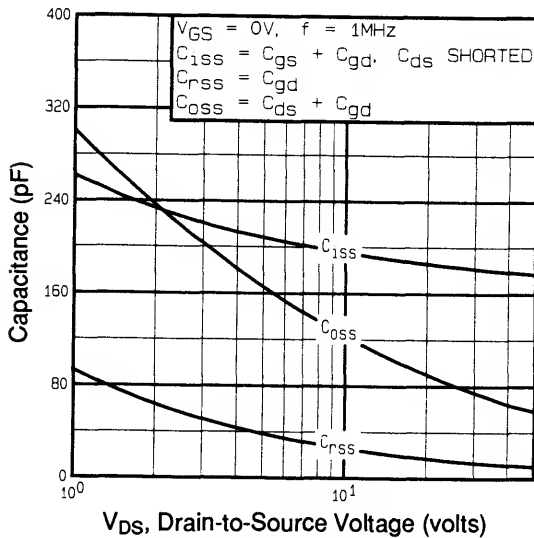
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	4.7	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	19		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}$ , $I_S=4.7A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	50	---	200	ns	$T_J=25^\circ\text{C}$ , $I_F=5.6A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.22	---	0.88	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

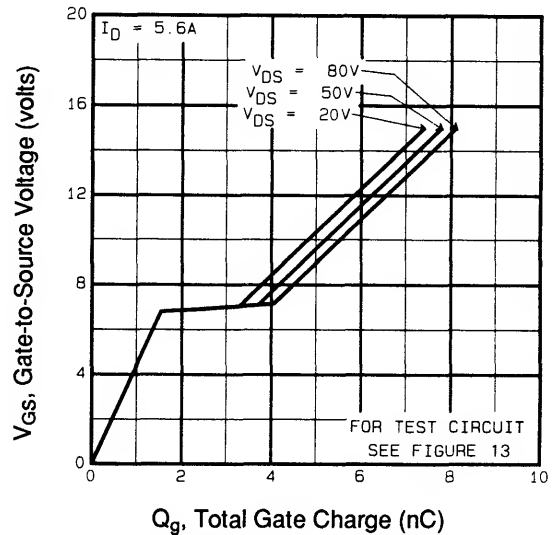
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=7.4\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=4.7A$  (See figure 12)
- ③  $I_{SD}\leq 4.7A$ ,  $di/dt\leq 75A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$



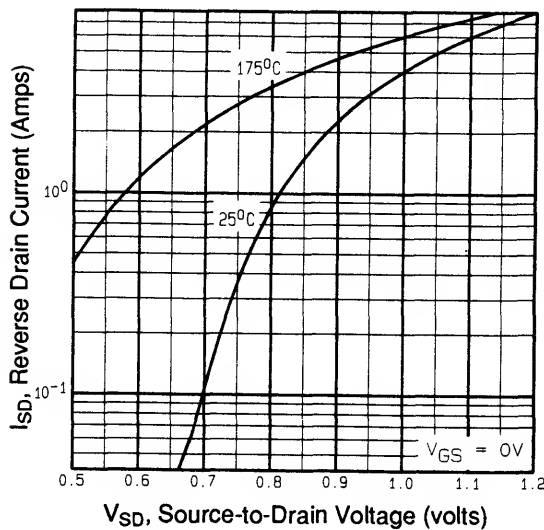




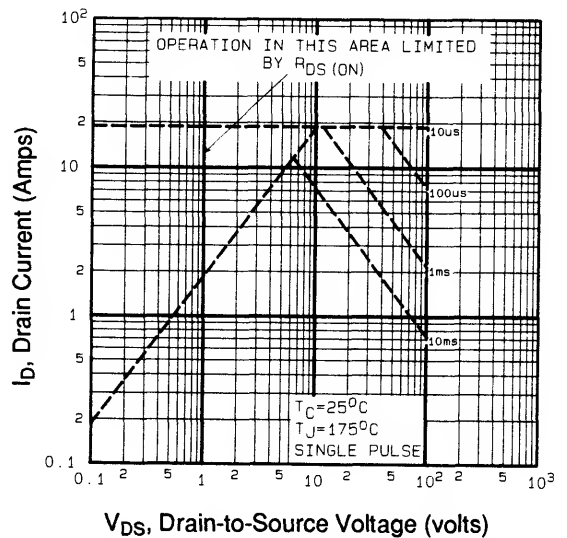
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



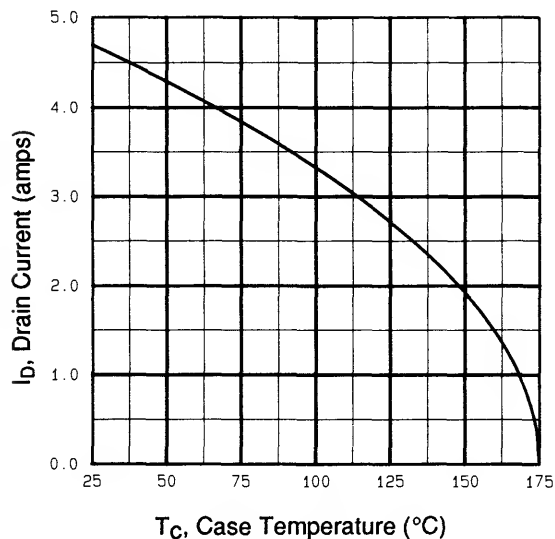
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



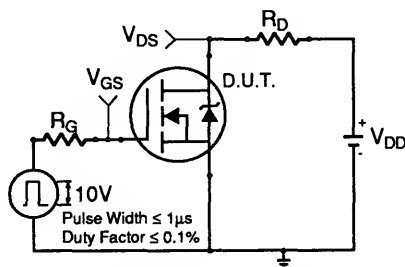
**Fig 7. Typical Source-Drain Diode Forward Voltage**



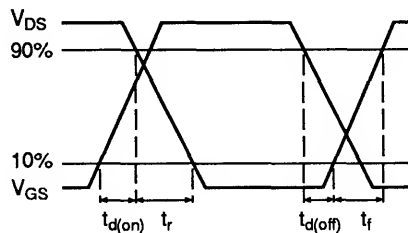
**Fig 8. Maximum Safe Operating Area**



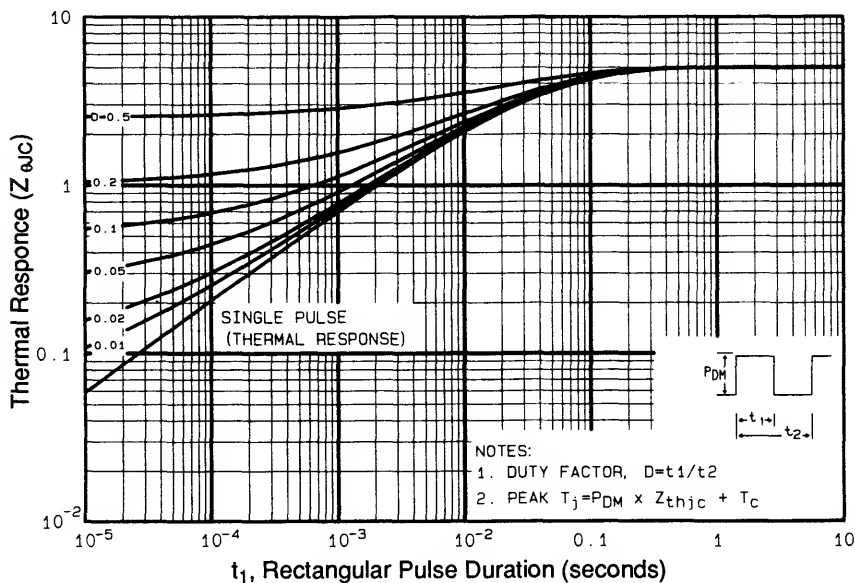
**Fig 9.** Maximum Drain Current Vs. Case Temperature



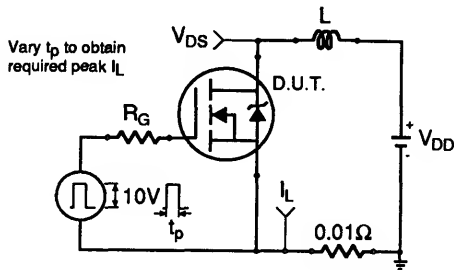
**Fig 10a.** Switching Time Test Circuit



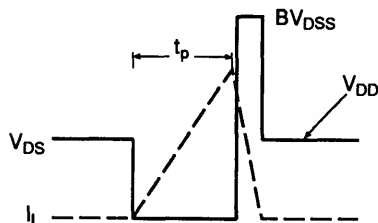
**Fig 10b.** Switching Time Waveforms



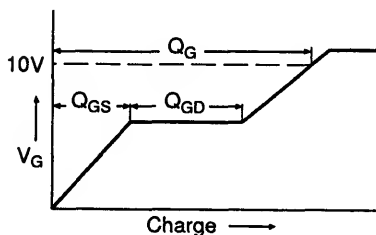
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



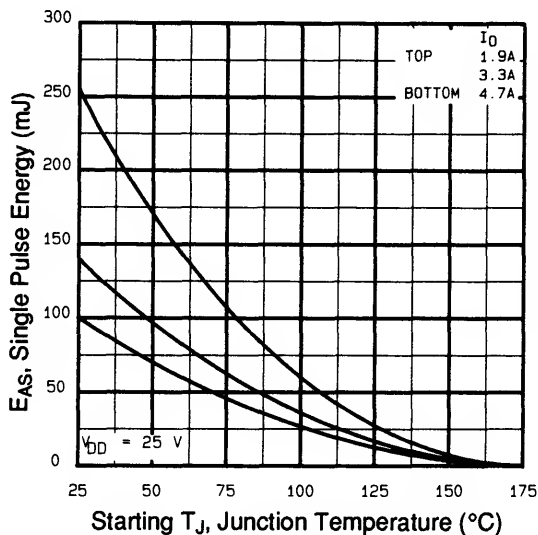
**Fig 12a.** Unclamped Inductive Test Circuit



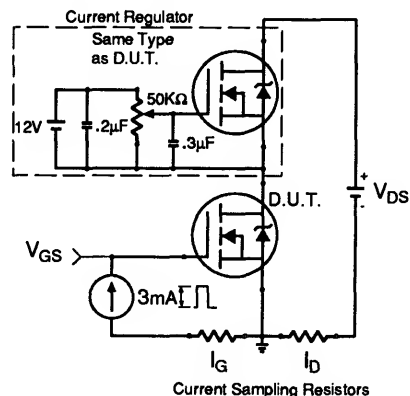
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

**Appendix D:** Part Marking Information

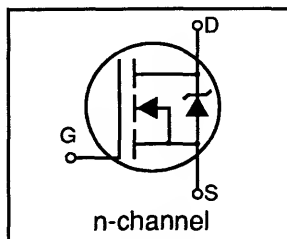
# International Rectifier

## IRFR120

## IRFU120

### HEXFET® Power MOSFET

- Surface Mount (IRFR120)
- Straight Lead (IRFU120)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

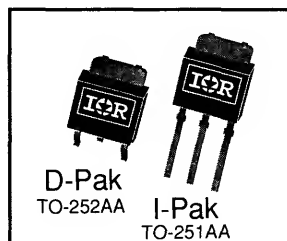


$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.27 $\Omega$   
 $I_D$  8.4A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

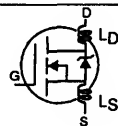
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	8.4	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	6.0	
$I_{DM}$	Pulsed Drain Current ①	34	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	50	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	210	mJ
$I_{AR}$	Avalanche Current ①	8.4	A
$E_{AR}$	Repetitive Avalanche Energy ①	5.0	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.13	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.27	$\Omega$	$V_{GS}=10V$ , $I_D=5.0A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.6	---	---	S	$V_{DS}=50V$ , $I_{DS}=5.0A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	16	nC	$I_D=9.2A$ , $V_{DS}=80V$ , $V_{GS}=10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	4.4		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.7		
$t_{d(on)}$	Turn-On Delay Time	---	6.8	---	ns	$V_{DD}=50V$ , $I_D=9.2A$ $R_G=18\Omega$ , $R_D=5.2\Omega$ See Fig. 10④
$t_r$	Rise Time	---	27	---		
$t_{d(off)}$	Turn-Off Delay Time	---	18	---		
$t_f$	Fall Time	---	17	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	360	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0\text{MHz}$ See Fig. 5
$C_{oss}$	Output Capacitance	---	150	---		
$C_{rss}$	Reverse Transfer Capacitance	---	34	---		

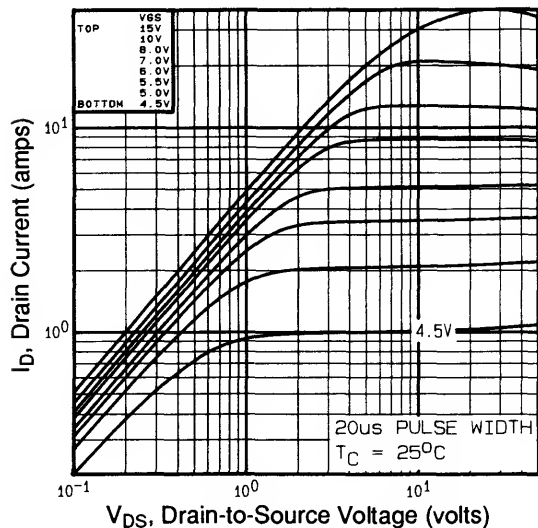


## Source-Drain Diode Ratings and Characteristics

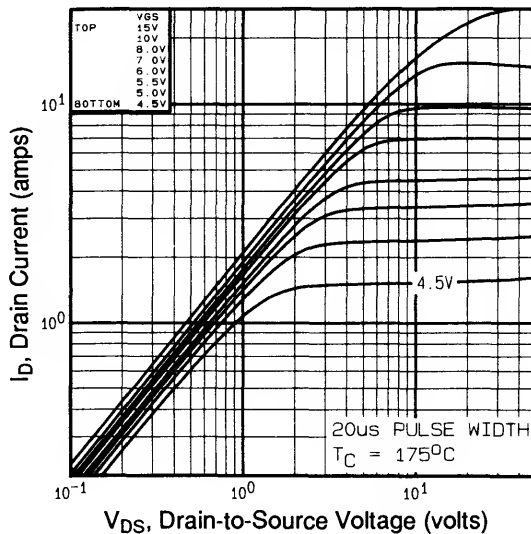
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	8.4	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	34		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}$ , $I_S=8.4A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	65	---	260	ns	$T_J=25^\circ\text{C}$ , $I_F=9.2A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.33	---	1.3	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

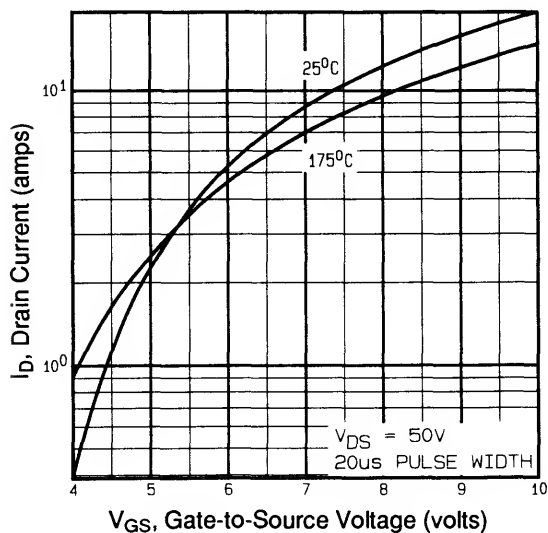
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=4.4\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=8.4A$  (See figure 12)
- ③  $I_{SD}\leq 8.4A$ ,  $di/dt\leq 110A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$



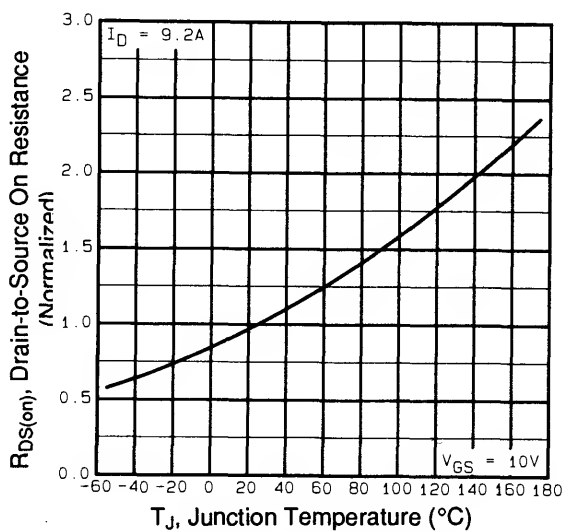
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



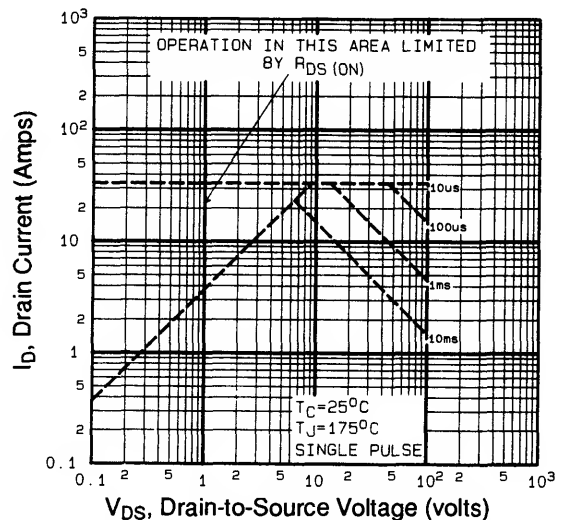
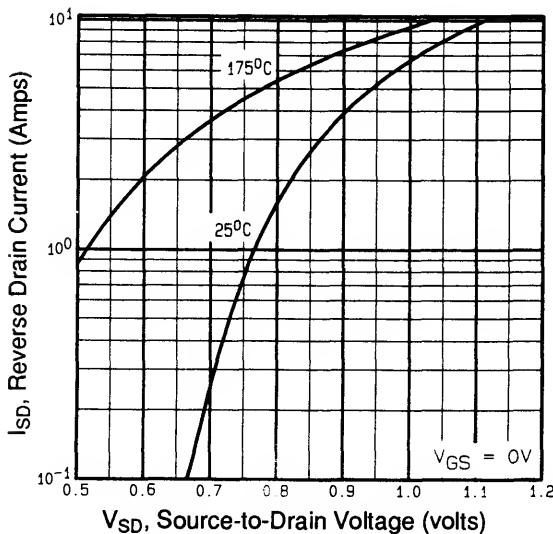
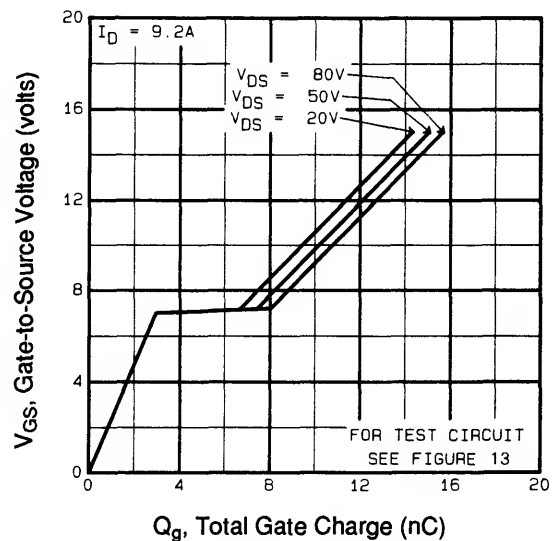
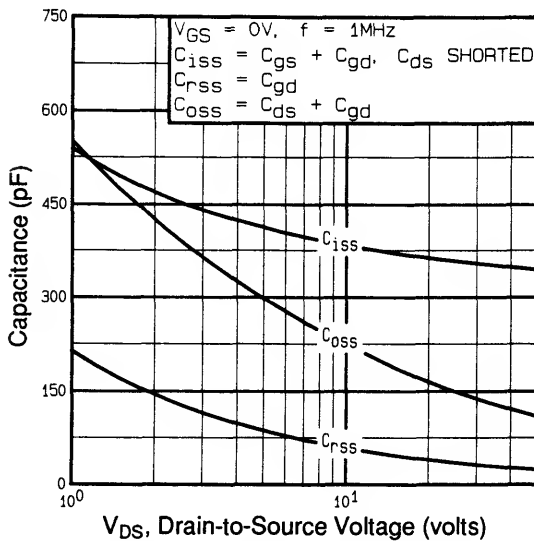
**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$



**Fig 3. Typical Transfer Characteristics**



**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**



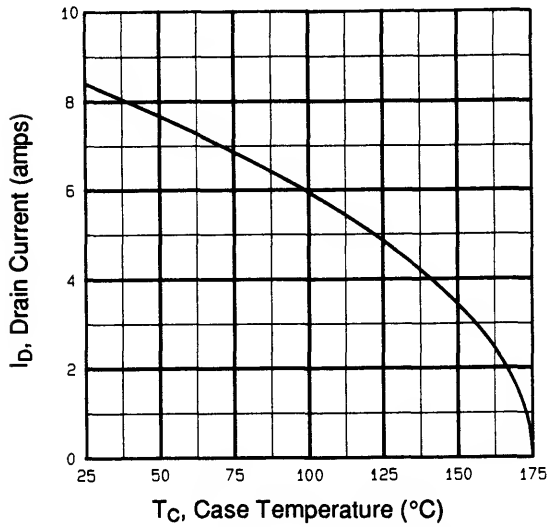


Fig 9. Maximum Drain Current Vs. Case Temperature

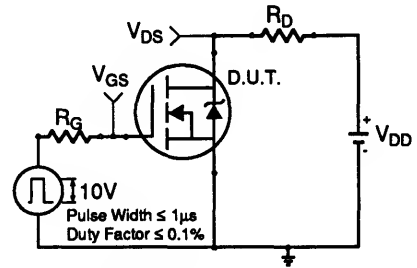


Fig 10a. Switching Time Test Circuit

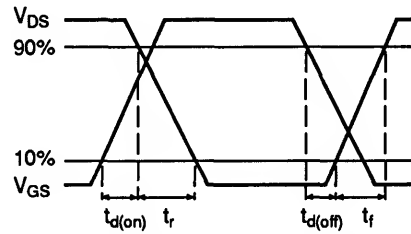


Fig 10b. Switching Time Waveforms

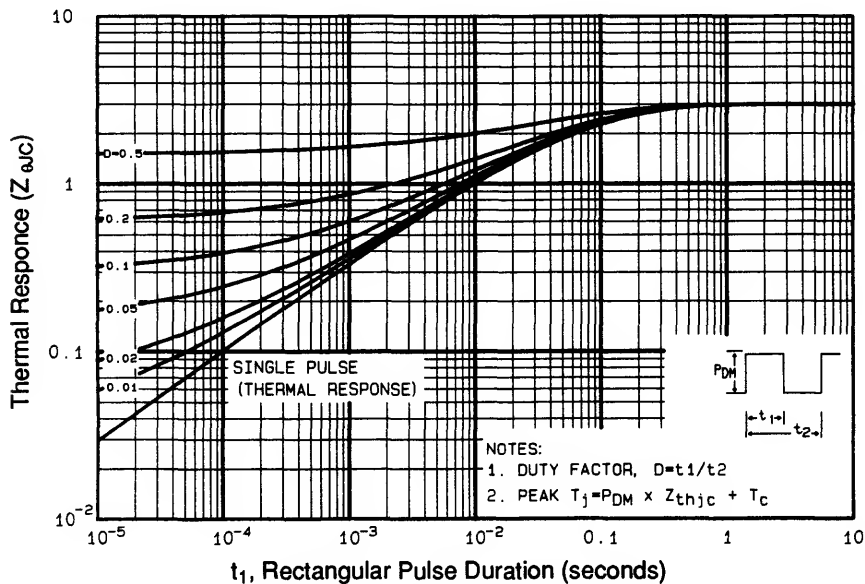
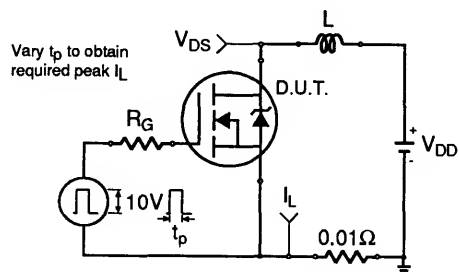
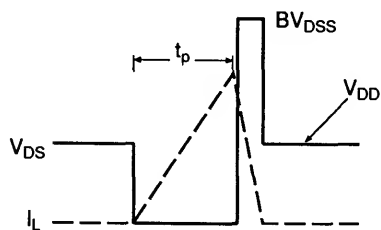


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

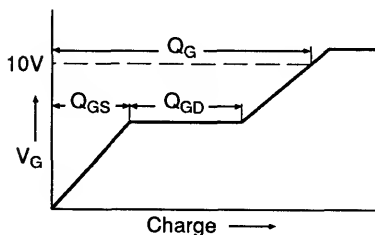




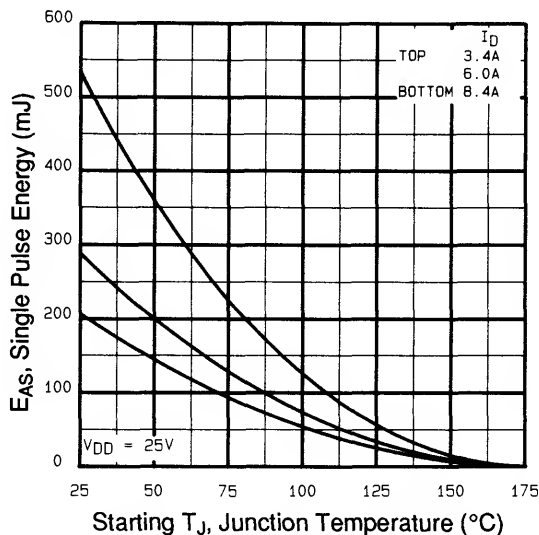
**Fig 12a.** Unclamped Inductive Test Circuit



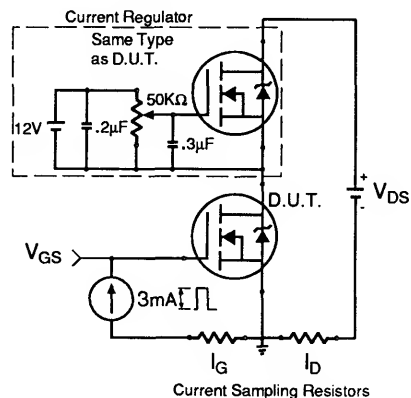
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

**Appendix D:** Part Marking Information

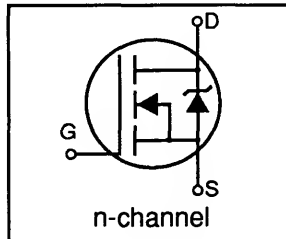
# International Rectifier

HEXFET® Power MOSFET

## IRFR210

## IRFU210

- Surface Mount (IRFR210)
- Straight Lead (IRFU210)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

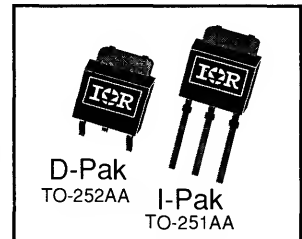


$BV_{DSS}$  200V  
 $R_{DS(on)}$  1.5 $\Omega$   
 $I_D$  2.6A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

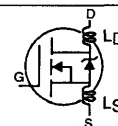
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	2.6	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.7	
$I_{DM}$	Pulsed Drain Current ①	8.0	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	64	mJ
$I_{AR}$	Avalanche Current ①	2.7	A
$E_{AR}$	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
$T_J$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
$T_{STG}$	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	200	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.30	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.5	$\Omega$	$V_{GS}=10V$ , $I_D=1.6A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.2	---	---	S	$V_{DS}=50V$ , $I_{DS}=1.6A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=200V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=160V$ , $V_{GS}=0V$ , $T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	8.2	nC	$I_D=3.3A$ , $V_{DS}=160V$ , $V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	1.8		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	4.5		
$t_{d(on)}$	Turn-On Delay Time	---	8.2	---	ns	$V_{DD}=100V$ , $I_D=3.3A$ $R_G=24\Omega$ , $R_D=30\Omega$ ④
$t_r$	Rise Time	---	17	---		
$t_{d(off)}$	Turn-Off Delay Time	---	14	---		
$t_f$	Fall Time	---	8.9	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	140	---	pF	$V_{GS}=0V$ , $V_{DS}=25$ $f=1.0\text{MHz}$
$C_{oss}$	Output Capacitance	---	53	---		
$C_{rss}$	Reverse Transfer Capacitance	---	15	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	2.7	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	8.0		
$V_{SD}$	Diode Forward Voltage	---	---	2.0	V	$T_J=25^\circ\text{C}$ , $I_S=2.7A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	75	---	310	ns	$T_J=25^\circ\text{C}$ , $I_F=3.3A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.33	---	1.4	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=16\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.6A$
- ③  $I_{SD}\leq 2.7A$ ,  $di/dt\leq 70A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

For more information on the same die in a HD-1 package refer to IRFD210.

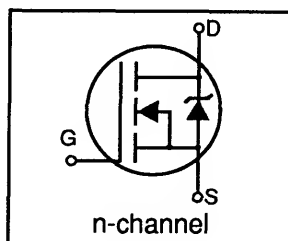


IRFR214

IRFU214

HEXFET® Power MOSFET

- Surface Mount (IRFR214)
- Straight Lead (IRFU214)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

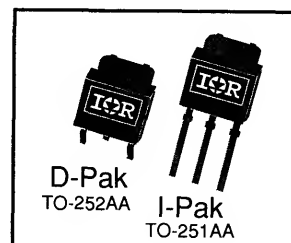


$BV_{DSS}$  250V  
 $R_{DS(on)}$  2.0Ω  
 $I_D$  2.2A

## Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



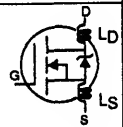
## Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	2.2	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.4	
$I_{DM}$	Pulsed Drain Current ①	8.8	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	±20	V
$E_{AS}$	Single Pulse Avalanche Energy ②	61	mJ
$I_{AR}$	Avalanche Current ①	2.2	A
$E_{AR}$	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	2.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

## Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	250	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.39	---	V/°C	Reference to 25°C, $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	2.0	$\Omega$	$V_{GS}=10V$ , $I_D=1.3A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.2	---	---	S	$V_{DS}=50V$ , $I_{DS}=1.3A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=250V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=200V$ , $V_{GS}=0V$ , $T_J=125^\circ C$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	8.2	nC	$I_D=2.7A$ , $V_{DS}=200V$ , $V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	1.8		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	4.5		
$t_{d(on)}$	Turn-On Delay Time	---	7.0	---	ns	$V_{DD}=125V$ , $I_D=2.7A$ $R_G=24\Omega$ , $R_D=45\Omega$ ④
$t_r$	Rise Time	---	7.6	---		
$t_{d(off)}$	Turn-Off Delay Time	---	16	---		
$t_f$	Fall Time	---	7.0	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	140	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	42	---		
$C_{rss}$	Reverse Transfer Capacitance	---	9.6	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	2.2	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	8.8		
$V_{SD}$	Diode Forward Voltage	---	---	2.0	V	$T_J=25^\circ C$ , $I_S=2.2A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	97	---	390	ns	$T_J=25^\circ C$ , $I_F=2.7A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.32	---	1.3	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)

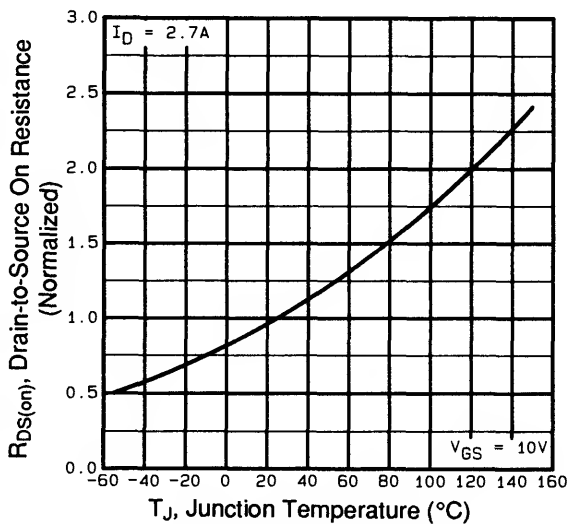
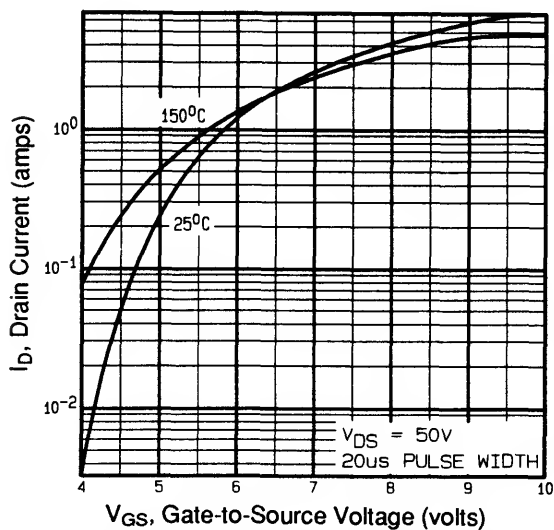
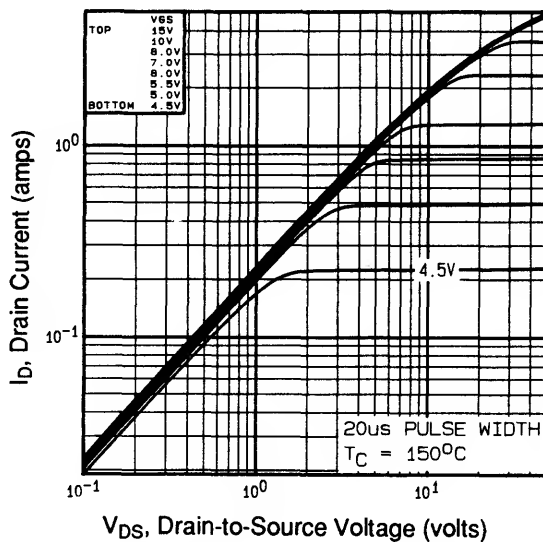
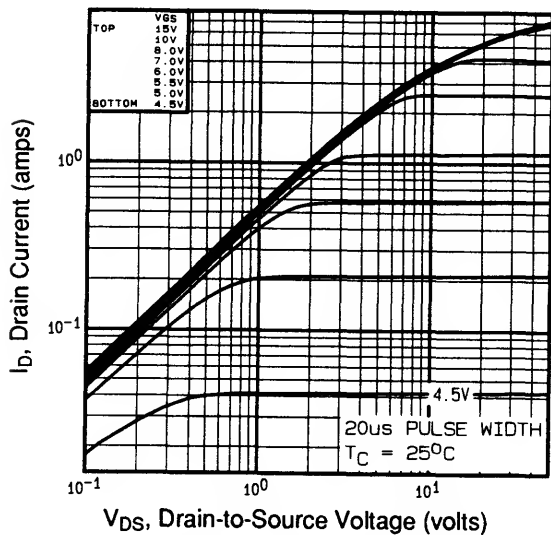
③  $I_{SD} \leq 2.2A$ ,  $di/dt \leq 65A/\mu s$ ,  $V_{DD} \leq BV_{DSS}$ ,  
 $T_J \leq 150^\circ C$  Suggested  $R_G=24\Omega$

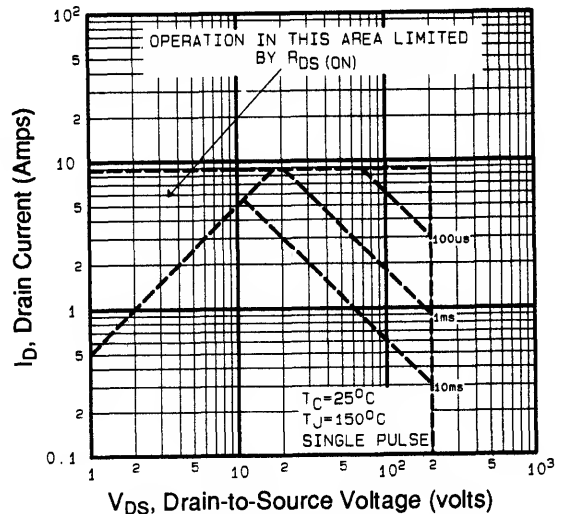
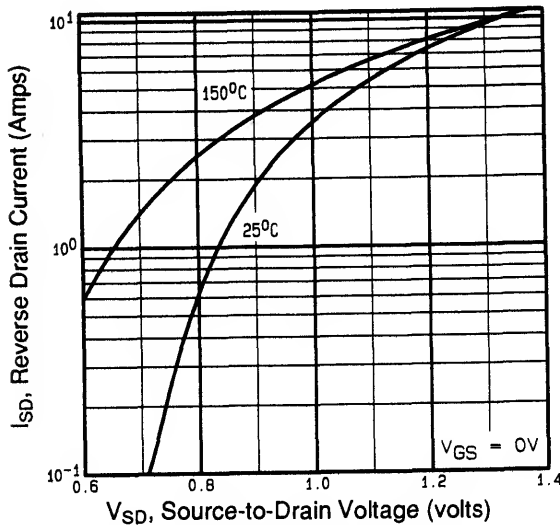
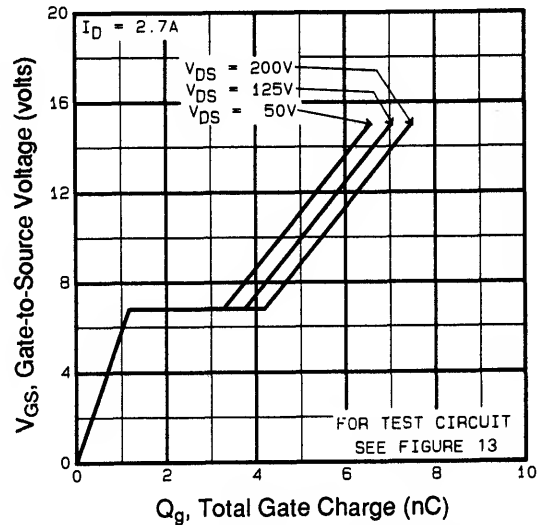
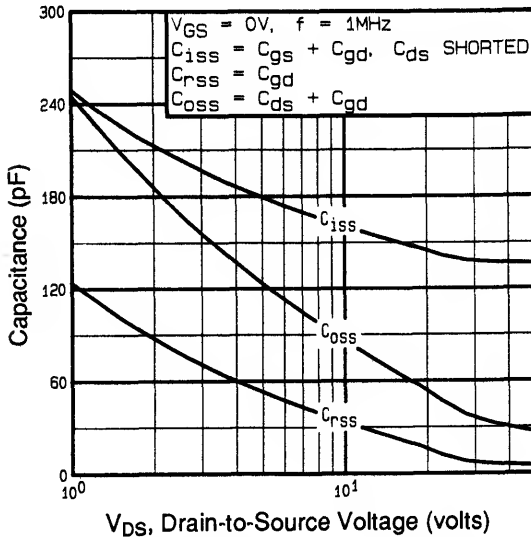
⑤ Mounting surface:  
flat, smooth, greased

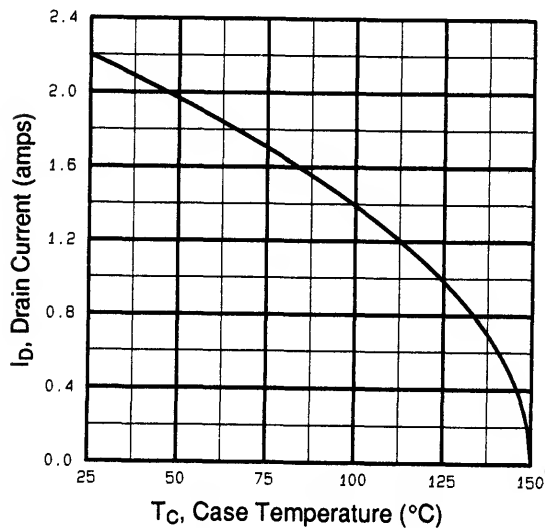
②  $V_{DD}=50V$ , Starting  $T_J=25^\circ C$ ,  $L=21mH$ ,  
 $R_G=25\Omega$ , Peak  $I_{AS}=2.2A$

④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$

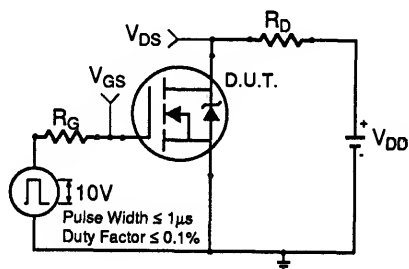
⑥  $K/W = ^\circ C/W$



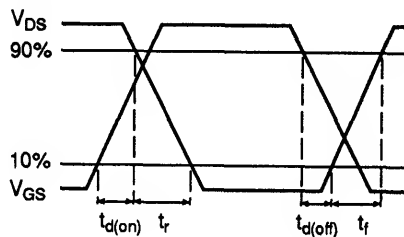




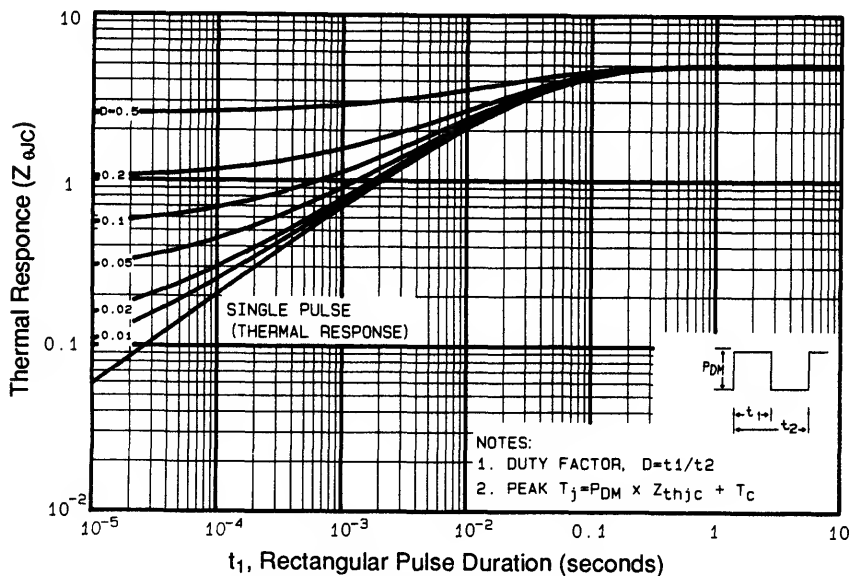
**Fig 9. Maximum Drain Current Vs. Case Temperature**



**Fig 10a. Switching Time Test Circuit**

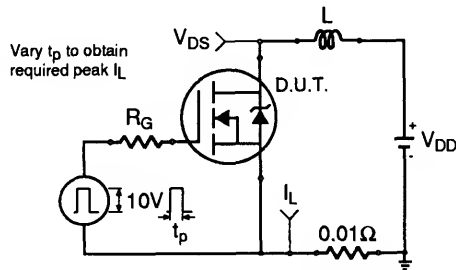


**Fig 10b. Switching Time Waveforms**

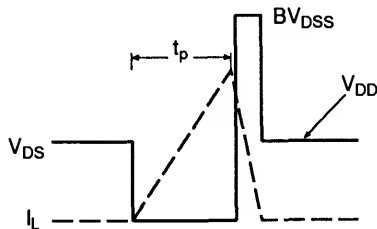


**Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case**

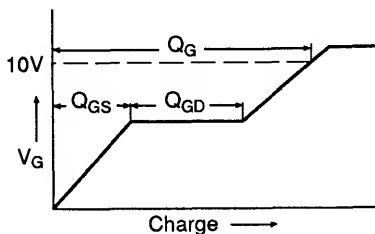




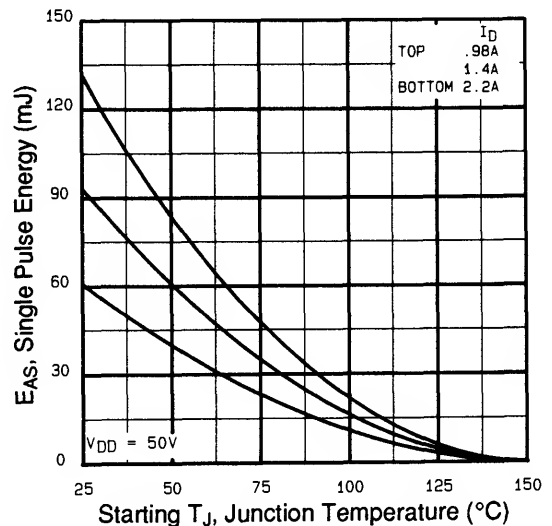
**Fig 12a.** Unclamped Inductive Test Circuit



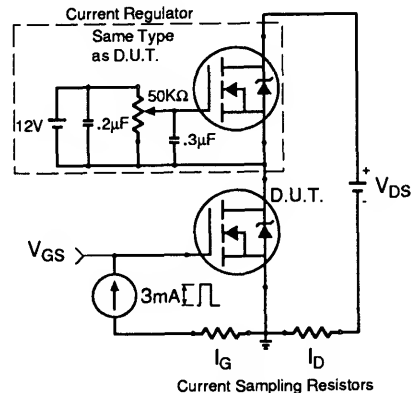
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

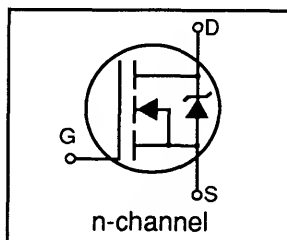
**Appendix D:** Part Marking Information

# International Rectifier

## IRFR220 IRFU220

HEXFET® Power MOSFET

- Surface Mount (IRFR220)
- Straight Lead (IRFU220)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

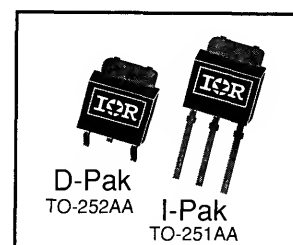


$BV_{DSS}$  200V  
 $R_{DS(on)}$  0.80 $\Omega$   
 $I_D$  4.8A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

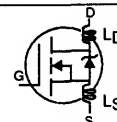
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	4.8	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	3.0	
$I_{DM}$	Pulsed Drain Current ①	18	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	42	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	130	mJ
$I_{AR}$	Avalanche Current ①	4.8	A
$E_{AR}$	Repetitive Avalanche Energy ①	4.2	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	200	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.29	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.80	$\Omega$	$V_{GS}=10V, I_D=2.9A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.7	---	---	S	$V_{DS}=50V, I_{DS}=2.9A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=200V, V_{GS}=0V$
		---	---	1000		$V_{DS}=160V, V_{GS}=0V, T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	14	nC	$I_D=5.2A, V_{DS}=160V, V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.9		
$t_{d(on)}$	Turn-On Delay Time	---	7.2	---	ns	$V_{DD}=100V, I_D=5.2A$ $R_G=18\Omega, R_D=19\Omega$ ④
$t_r$	Rise Time	---	22	---		
$t_{d(off)}$	Turn-Off Delay Time	---	19	---		
$t_f$	Fall Time	---	13	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	260	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0\text{Mhz}$
$C_{oss}$	Output Capacitance	---	100	---		
$C_{rss}$	Reverse Transfer Capacitance	---	30	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	4.8	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	18		
$V_{SD}$	Diode Forward Voltage	---	---	1.8	V	$T_J=25^\circ\text{C}, I_S=4.8A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	75	---	300	ns	$T_J=25^\circ\text{C}, I_F=5.2A, di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.46	---	1.8	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=8.5\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=4.8A$
- ③  $I_{SD}\leq 4.8A$ ,  $di/dt\leq 95A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

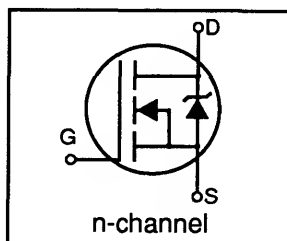
# International Rectifier

HEXFET® Power MOSFET

## IRFR224

## IRFU224

- Surface Mount (IRFR224)
- Straight Lead (IRFU224)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

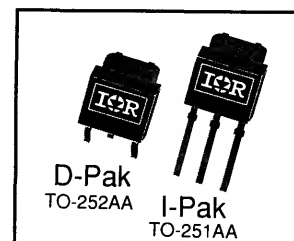


$BV_{DSS}$  250V  
 $R_{DS(on)}$  1.1 $\Omega$   
 $I_D$  3.8A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

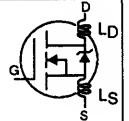
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	3.8	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	2.4	
$I_{DM}$	Pulsed Drain Current ①	14	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	42	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	130	mJ
$I_{AR}$	Avalanche Current ①	3.8	A
$E_{AR}$	Repetitive Avalanche Energy ①	4.2	mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.8	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	250	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.36	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.1	$\Omega$	$V_{GS}=10V, I_D=2.3A^{(4)}$
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.7	---	---	S	$V_{DS}=5.0V, I_{DS}=2.3A^{(4)}$
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=250V, V_{GS}=0V$
		---	---	1000		$V_{DS}=200V, V_{GS}=0V, T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	14	nC	$I_D=4.4A, V_{DS}=200V, V_{GS}=10V^{(4)}$
$Q_{gs}$	Gate-to-Source Charge	---	---	2.7		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.8		
$t_{d(on)}$	Turn-On Delay Time	---	7.0	---	ns	$V_{DD}=125V, I_D=4.4A, R_G=18\Omega, R_D=28\Omega^{(4)}$
$t_r$	Rise Time	---	13	---		
$t_{d(off)}$	Turn-Off Delay Time	---	20	---		
$t_f$	Fall Time	---	12	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	260	---	pF	$V_{GS}=0V, V_{DS}=25V, f=1.0\text{Mhz}$
$C_{oss}$	Output Capacitance	---	77	---		
$C_{rss}$	Reverse Transfer Capacitance	---	15	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	3.8	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) <sup>(1)</sup>	---	---	14		
$V_{SD}$	Diode Forward Voltage	---	---	1.8	V	$T_J=25^\circ\text{C}, I_S=3.8A, V_{GS}=0V^{(4)}$
$t_{rr}$	Reverse Recovery Time	100	---	400	ns	$T_J=25^\circ\text{C}, I_F=4.4A, di/dt=100A/\mu S^{(4)}$
$Q_{RR}$	Reverse Recovery Charge	0.47	---	1.9	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

① Repetitive rating; Pulse width limited by max. junction temperature

③  $I_{SD} \leq 3.8A, di/dt \leq 90A/\mu s, V_{DD} \leq BV_{DSS}, T_J \leq 150^\circ\text{C}$  Suggested  $R_G=18\Omega$

⑤ Mounting surface: flat, smooth, greased

②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=14\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=3.8A$

④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$

⑥  $K/W = ^\circ\text{C/W}$

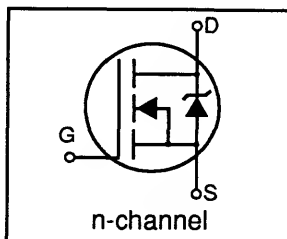
# International Rectifier

HEXFET® Power MOSFET

## IRFR310

## IRFU310

- Surface Mount (IRFR310)
- Straight Lead (IRFU310)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

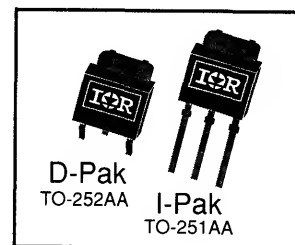


$BV_{DSS}$  400V  
 $R_{DS(on)}$  3.6Ω  
 $I_D$  1.7A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

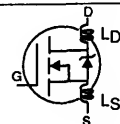
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.7	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.1	
$I_{DM}$	Pulsed Drain Current ①	5.0	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	±20	V
$E_{AS}$	Single Pulse Avalanche Energy ②	86	mJ
$I_{AR}$	Avalanche Current ①	1.7	A
$E_{AR}$	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	400	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.47	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	3.6	$\Omega$	$V_{GS}=10V, I_D=1.0A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.97	---	---	S	$V_{DS}=50V, I_{DS}=1.0A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=400V, V_{GS}=0V$
		---	---	1000		$V_{DS}=320V, V_{GS}=0V, T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	12	nC	$I_D=2.0A, V_{DS}=320V, V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	1.9		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	6.5		
$t_{d(on)}$	Turn-On Delay Time	---	7.9	---	ns	$V_{DD}=200V, I_D=2.0A$ $R_G=24\Omega, R_D=95\Omega$ ④
$t_r$	Rise Time	---	9.9	---		
$t_{d(off)}$	Turn-Off Delay Time	---	21	---		
$t_f$	Fall Time	---	11	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	170	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0\text{Mhz}$
$C_{oss}$	Output Capacitance	---	34	---		
$C_{rss}$	Reverse Transfer Capacitance	---	6.3	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	1.7	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	4.3		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}, I_S=1.7A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	120	---	540	ns	$T_J=25^\circ\text{C}, I_F=2.0A, di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.32	---	1.6	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=32\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=1.7A$
- ③  $I_{SD}\leq 1.7A$ ,  $di/dt\leq 40A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

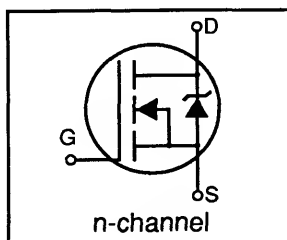
# International Rectifier

HEXFET® Power MOSFET

## IRFR320

## IRFU320

- Surface Mount (IRFR320)
- Straight Lead (IRFU320)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

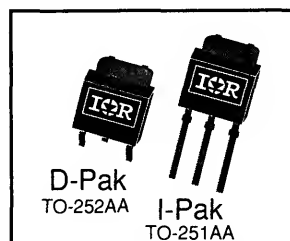


$BV_{DSS}$  400V  
 $R_{DS(on)}$  1.8 $\Omega$   
 $I_D$  3.1A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	3.1	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	2.0	
$I_{DM}$	Pulsed Drain Current ①	11	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	42	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	160	mJ
$I_{AR}$	Avalanche Current ①	3.1	A
$E_{AR}$	Repetitive Avalanche Energy ①	4.2	mJ
dv/dt	Peak Diode Recovery dv/dt ③	4.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

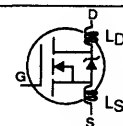
### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	



## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	400	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.51	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.8	$\Omega$	$V_{GS}=10V$ , $I_D=1.9A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.5	---	---	S	$V_{DS}=50V$ , $I_{DS}=1.9A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=400V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=320V$ , $V_{GS}=0V$ , $T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	$nA$	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	20		$I_D=3.3A$ , $V_{DS}=320V$ , $V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.3	nC	
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	11		
$t_{d(on)}$	Turn-On Delay Time	---	10	---	ns	$V_{DD}=200V$ , $I_D=3.3A$ $R_G=18\Omega$ , $R_D=56\Omega$ ④
$t_r$	Rise Time	---	14	---		
$t_{d(off)}$	Turn-Off Delay Time	---	30	---		
$t_f$	Fall Time	---	13	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	350	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0\text{MHz}$
$C_{oss}$	Output Capacitance	---	64	---		
$C_{rss}$	Reverse Transfer Capacitance	---	8.1	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	3.1	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	11		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}$ , $I_S=3.1A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	120	---	600	ns	$T_J=25^\circ\text{C}$ , $I_F=3.3A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.64	---	3.0	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=20\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=3.1A$
- ③  $I_{SD}\leq 3.1A$ ,  $di/dt\leq 65A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

For more information on the same die in a TO-220 package refer to IRF720.

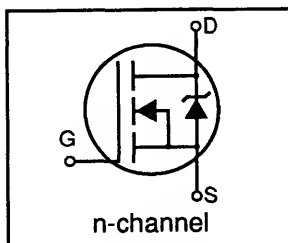
# International Rectifier

HEXFET® Power MOSFET

## IRFR420

## IRFU420

- Surface Mount (IRFR420)
- Straight Lead (IRFU420)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

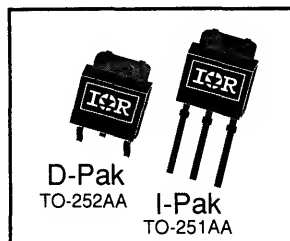


$BV_{DSS}$  500V  
 $R_{DS(on)}$  3.0Ω  
 $I_D$  2.4A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



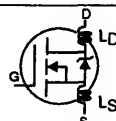
### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	2.4	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.5	
$I_{DM}$	Pulsed Drain Current ①	8.0	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	42	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	170	mJ
$I_{AR}$	Avalanche Current ①	2.4	A
$E_{AR}$	Repetitive Avalanche Energy ①	4.2	mJ
dv/dt	Peak Diode Recovery dv/dt ③	3.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

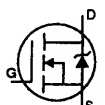
### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	500	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.59	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	3.0	$\Omega$	$V_{GS}=10V, I_D=1.4A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.0	---	---	S	$V_{DS}=50V, I_{DS}=1.4A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=500V, V_{GS}=0V$
		---	---	1000		$V_{DS}=400V, V_{GS}=0V, T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	$nA$	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	19		$I_D=2.1A, V_{DS}=400V, V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.3	nC	
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	13		
$t_{d(on)}$	Turn-On Delay Time	---	8.0	---	ns	$V_{DD}=250V, I_D=2.1A$ $R_G=18\Omega, R_D=120\Omega$ ④
$t_r$	Rise Time	---	8.6	---		
$t_{d(off)}$	Turn-Off Delay Time	---	33	---		
$t_f$	Fall Time	---	16	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact. 
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	360	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0\text{MHz}$
$C_{oss}$	Output Capacitance	---	92	---		
$C_{rss}$	Reverse Transfer Capacitance	---	37	---		

## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	2.4	A	MOSFET symbol showing the integral reverse p-n junction diode. 
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	8.0		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}, I_S=2.4A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	130	---	520	ns	$T_J=25^\circ\text{C}, I_F=2.1A,$
$Q_{RR}$	Reverse Recovery Charge	0.35	---	1.4	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=34\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.4A$
- ③  $I_{SD}\leq 2.4A$ ,  $di/dt\leq 50A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

For more information on the same die in a TO-220 package refer to IRF820.

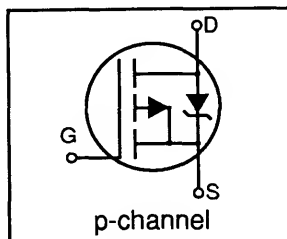
# International Rectifier

## IRFR9014

## IRFU9014

### HEXFET® Power MOSFET

- Surface Mount (IRFR9014)
- Straight Lead (IRFU9014)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- P-Channel

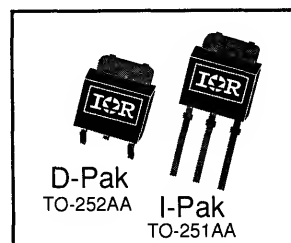


$BV_{DSS}$  -60V  
 $R_{DS(on)}$  0.50 $\Omega$   
 $I_D$  -5.6A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

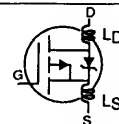
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10\text{V}$	-5.6	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10\text{V}$	-3.9	
$I_{DM}$	Pulsed Drain Current ①	-22	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	30	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	-5.6	A
$E_{AR}$	Repetitive Avalanche Energy ①	3.0	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-60	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.061	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.50	$\Omega$	$V_{GS}=-10V$ , $I_D=-3.4A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	1.4	---	---	S	$V_{DS}=-25V$ , $I_{DS}=-3.4A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-60V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-48V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	10	nC	$I_D=-5.6A$ , $V_{DS}=-48V$ , $V_{GS}=-10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.6		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	5.7		
$t_{d(on)}$	Turn-On Delay Time	---	11	---	ns	$V_{DD}=-30V$ , $I_D=-5.6A$ $R_G=24\Omega$ , $R_D=4.9\Omega$ See Fig. 10④
$t_r$	Rise Time	---	40	---		
$t_{d(off)}$	Turn-Off Delay Time	---	13	---		
$t_f$	Fall Time	---	17	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	280	---	pF	$V_{GS}=0V$ , $V_{DS}=-25V$ $f=1.0MHz$ See Fig. 5
$C_{oss}$	Output Capacitance	---	170	---		
$C_{rss}$	Reverse Transfer Capacitance	---	37	---		

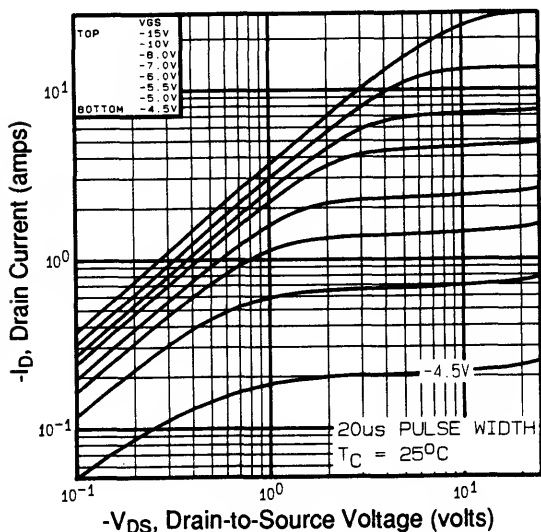


## Source-Drain Diode Ratings and Characteristics

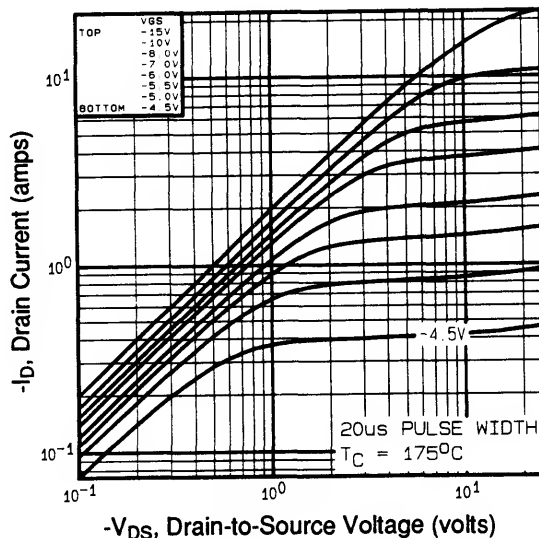
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-5.6	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-22		
$V_{SD}$	Diode Forward Voltage	---	---	-5.5	V	$T_J=25^\circ\text{C}$ , $I_S=-5.6A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	35	---	140	ns	$T_J=25^\circ\text{C}$ , $I_F=-5.6A$ , $di/dt=-100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.049	---	0.20	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

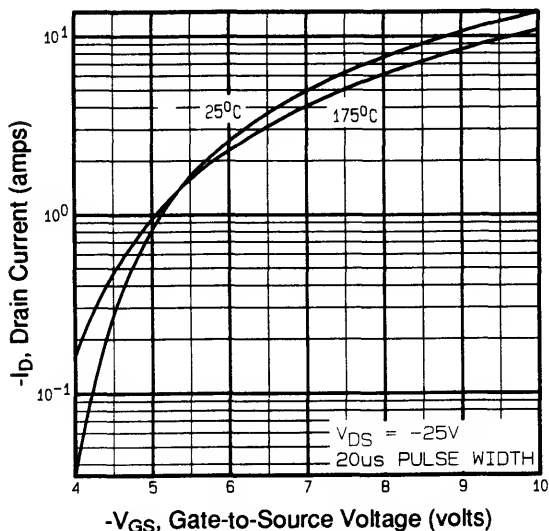
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=-25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=5.3mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-5.6A$  (See figure 12)
- ③  $I_{SD}\leq-5.6A$ ,  $di/dt\leq-90A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$



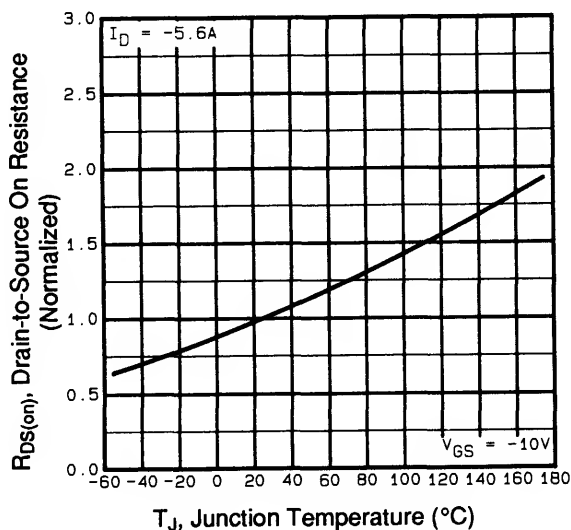
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



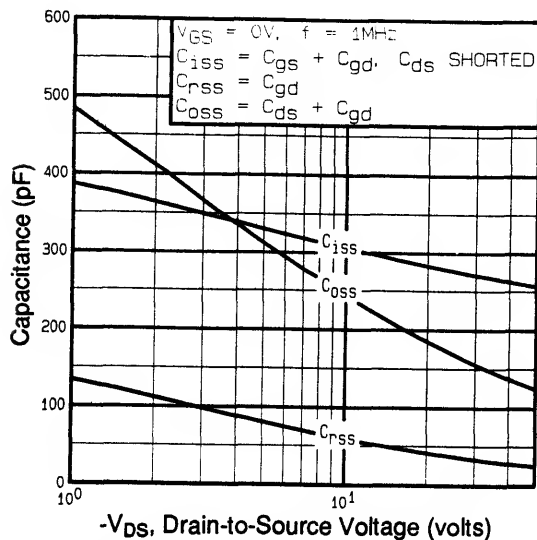
**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$



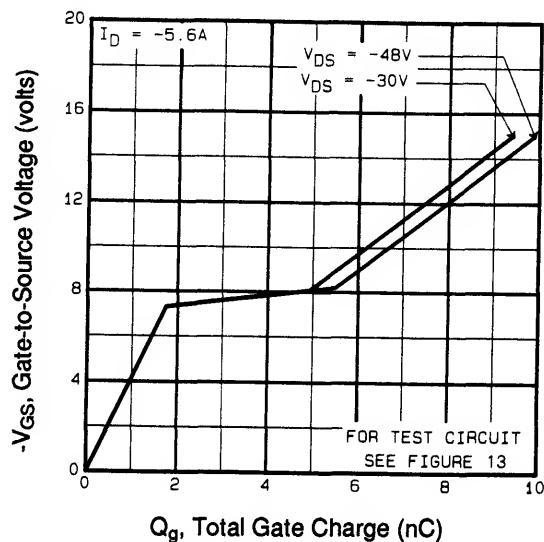
**Fig 3. Typical Transfer Characteristics**



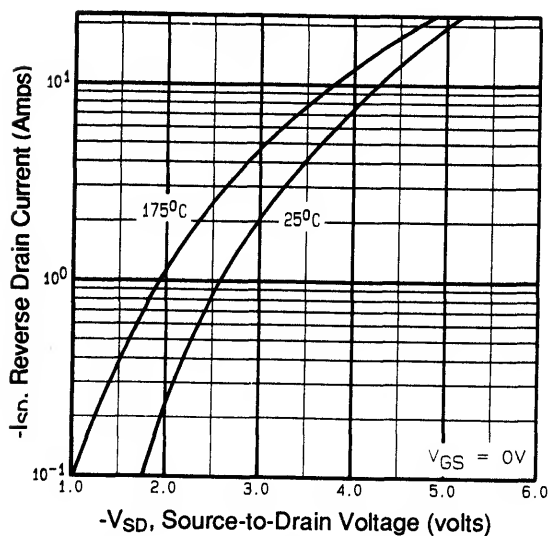
**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**



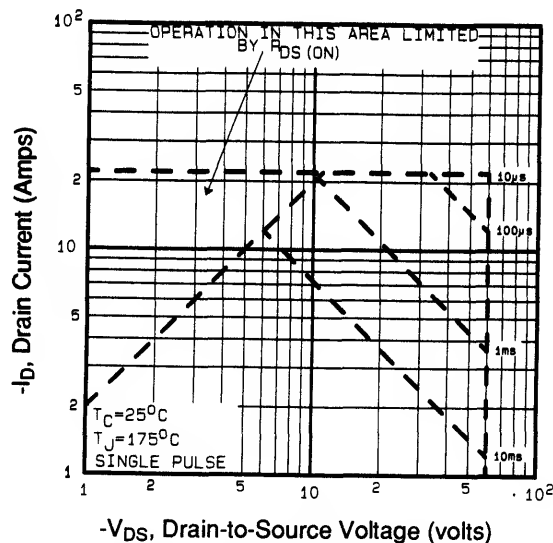
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



**Fig 7. Typical Source-Drain Diode Forward Voltage**



**Fig 8. Maximum Safe Operating Area**

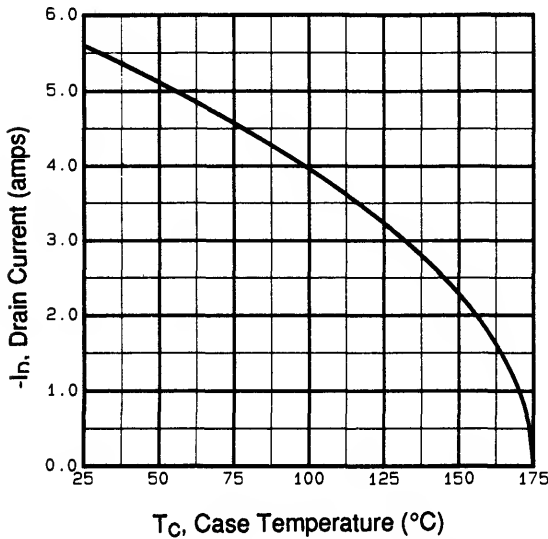


Fig 9. Maximum Drain Current Vs. Case Temperature

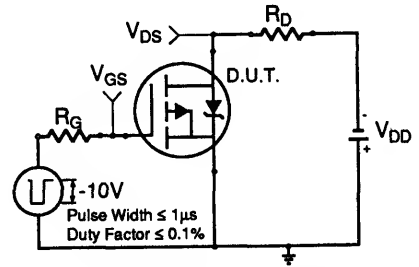


Fig 10a. Switching Time Test Circuit

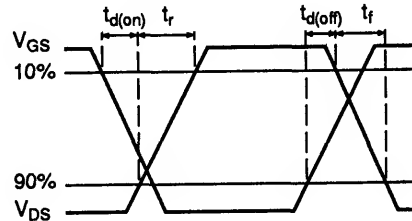


Fig 10b. Switching Time Waveforms

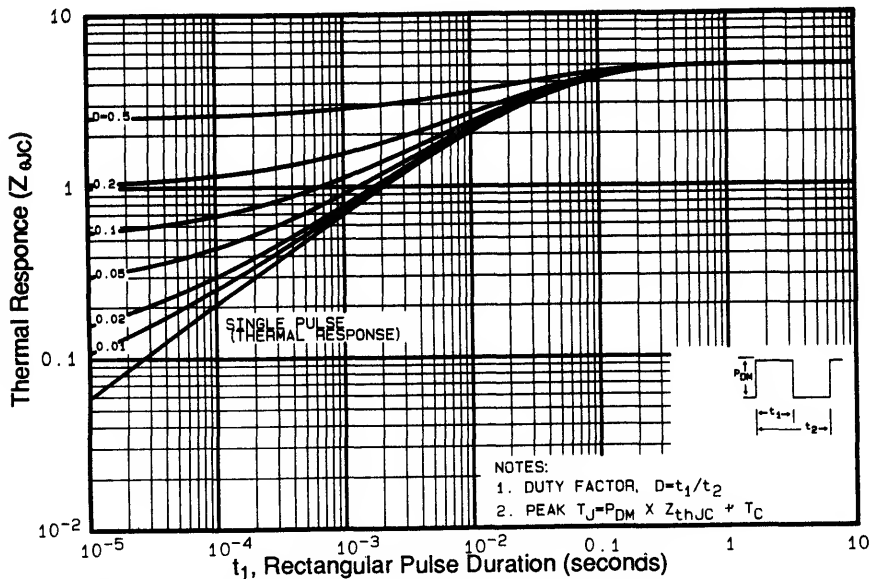
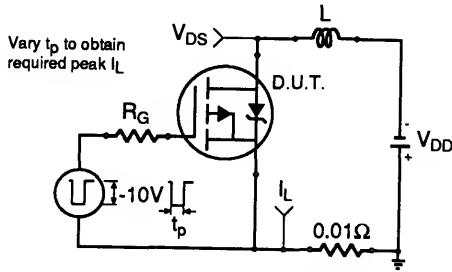
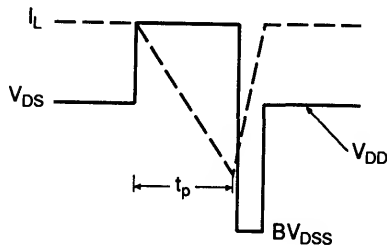


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

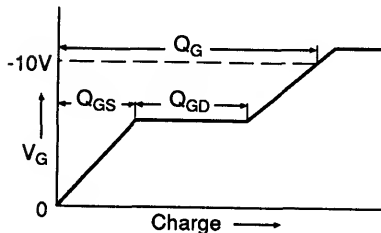




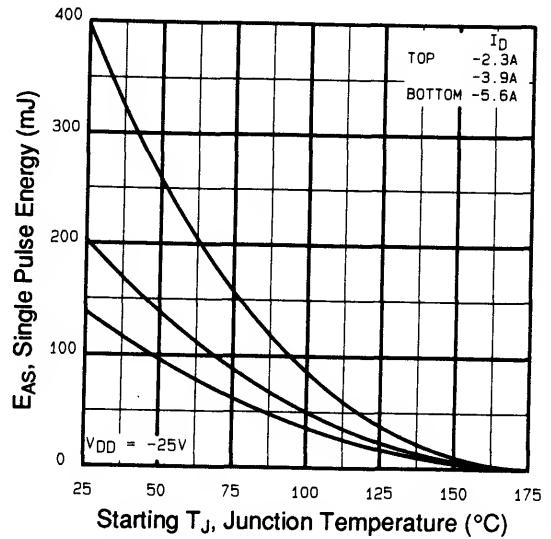
**Fig 12a.** Unclamped Inductive Test Circuit



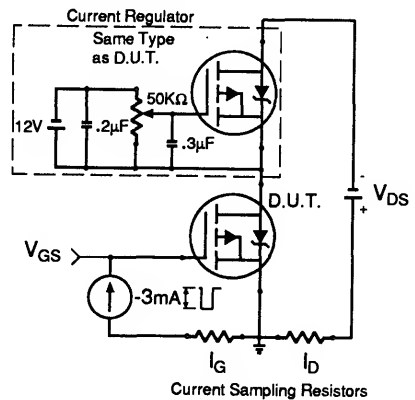
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

**Appendix D:** Part Marking Information

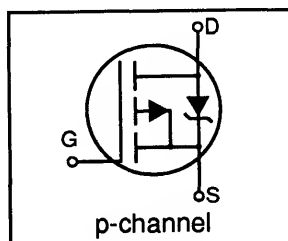
# International Rectifier

HEXFET® Power MOSFET

## IRFR9024

## IRFU9024

- Surface Mount (IRFR9024)
- Straight Lead (IRFU9024)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- P-Channel

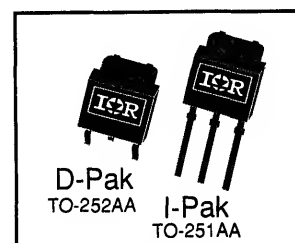


$BV_{DSS}$  -60V  
 $R_{DS(on)}$  0.28 $\Omega$   
 $I_D$  -9.6A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

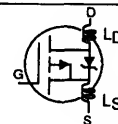
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS} = -10\text{V}$	-9.6	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS} = -10\text{V}$	-6.8	
$I_{DM}$	Pulsed Drain Current ①	-38	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	50	W
	Linear Derating Factor	0.33	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	300	mJ
$I_{AR}$	Avalanche Current ①	-9.6	A
$E_{AR}$	Repetitive Avalanche Energy ①	5.0	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W④
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-60	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.056	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.28	$\Omega$	$V_{GS}=-10V$ , $I_D=-5.8A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	3.9	---	---	S	$V_{DS}=-25V$ , $I_{DS}=-5.8A$ ④
$I_{BSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-60V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-48V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	19	nC	$I_D=-11A$ , $V_{DS}=-48V$ , $V_{GS}=-10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	5.4		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	11		
$t_{d(on)}$	Turn-On Delay Time	---	13	---	ns	$V_{DD}=-30V$ , $I_D=-11A$ $R_G=18\Omega$ , $R_D=2.5\Omega$ See Fig. 10④
$t_r$	Rise Time	---	68	---		
$t_{d(off)}$	Turn-Off Delay Time	---	15	---		
$t_f$	Fall Time	---	29	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	570	---	pF	$V_{GS}=0V$ , $V_{DS}=-25V$ $f=1.0MHz$ See Fig. 5
$C_{oss}$	Output Capacitance	---	360	---		
$C_{rss}$	Reverse Transfer Capacitance	---	65	---		

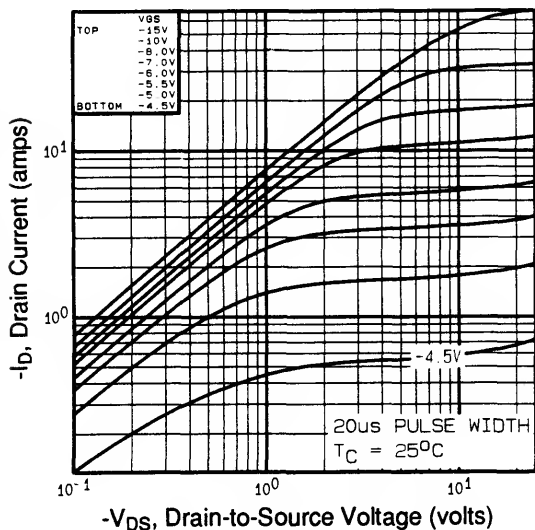


## Source-Drain Diode Ratings and Characteristics

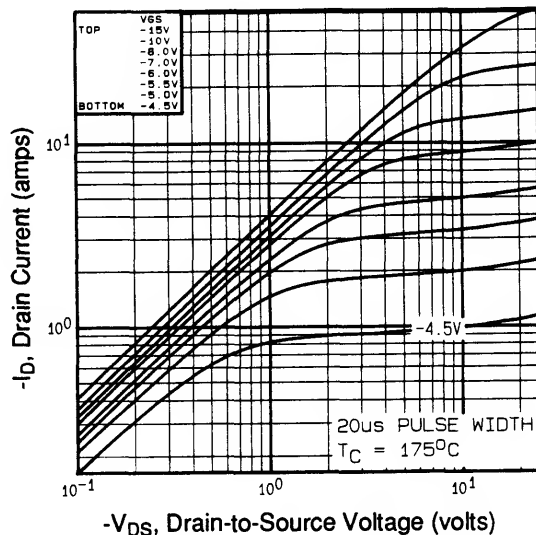
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-9.6	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-38		
$V_{SD}$	Diode Forward Voltage	---	---	-6.3	V	$T_J=25^\circ\text{C}$ , $I_S=-9.6A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	50	---	200	ns	$T_J=25^\circ\text{C}$ , $I_F=-11A$ ,
$Q_{RR}$	Reverse Recovery Charge	0.16	---	0.64	$\mu C$	$di/dt=-100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

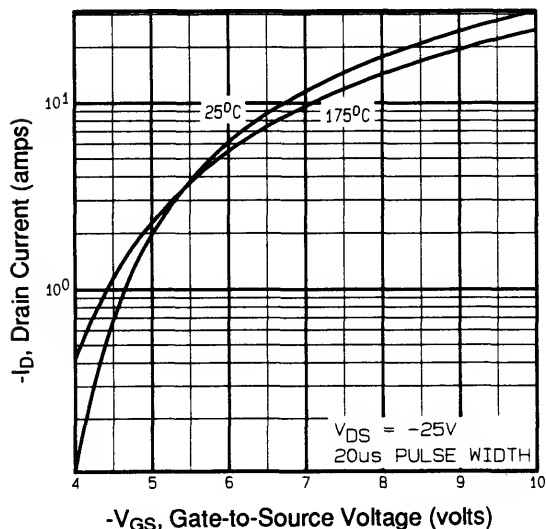
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=-25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=4.0mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-9.6A$  (See figure 12)
- ③  $I_{SD}\leq 9.6A$ ,  $di/dt\leq 140A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ C/W$



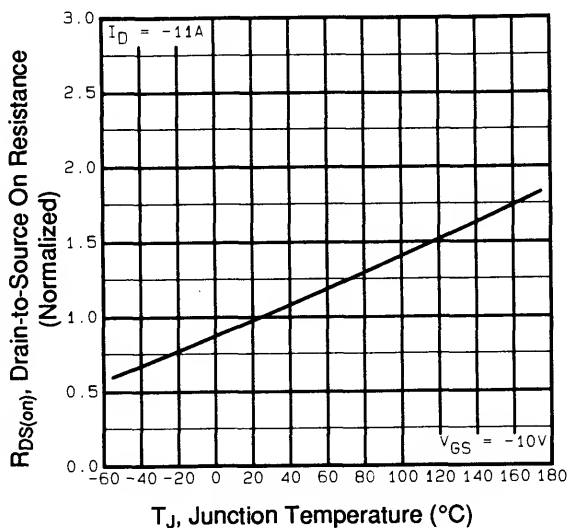
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



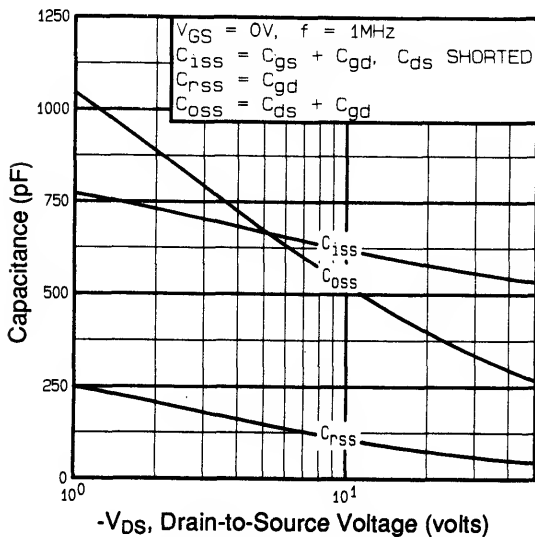
**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$



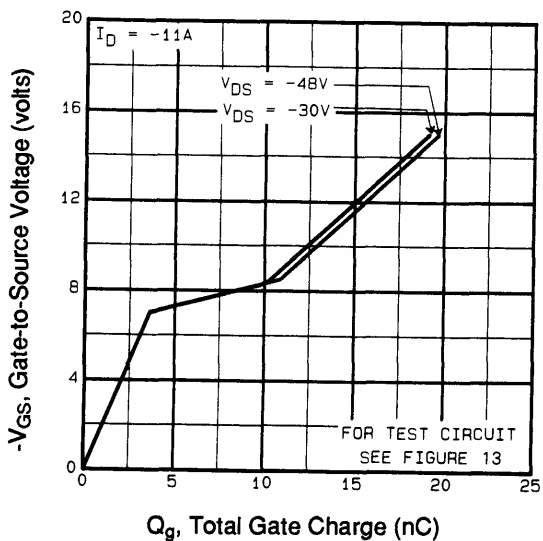
**Fig 3. Typical Transfer Characteristics**



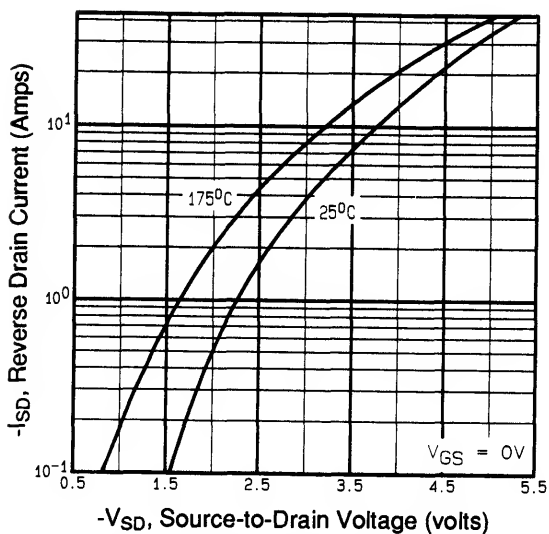
**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**



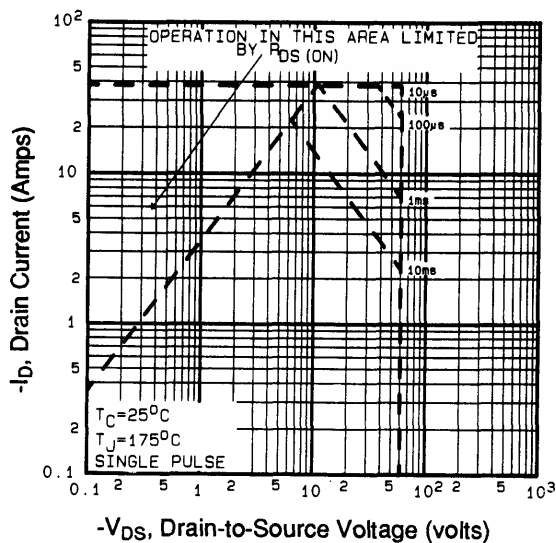
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



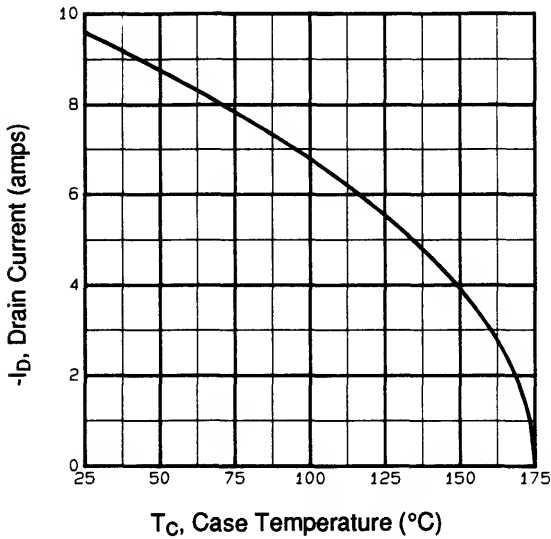
**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



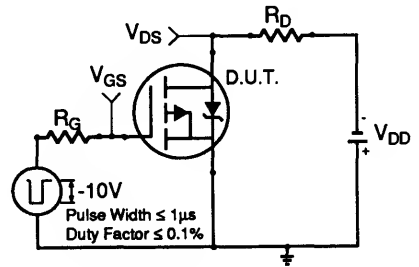
**Fig 7. Typical Source-Drain Diode Forward Voltage**



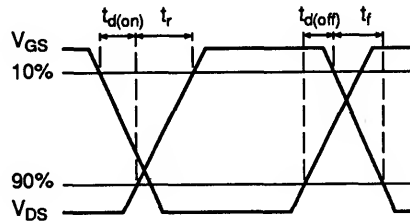
**Fig 8. Maximum Safe Operating Area**



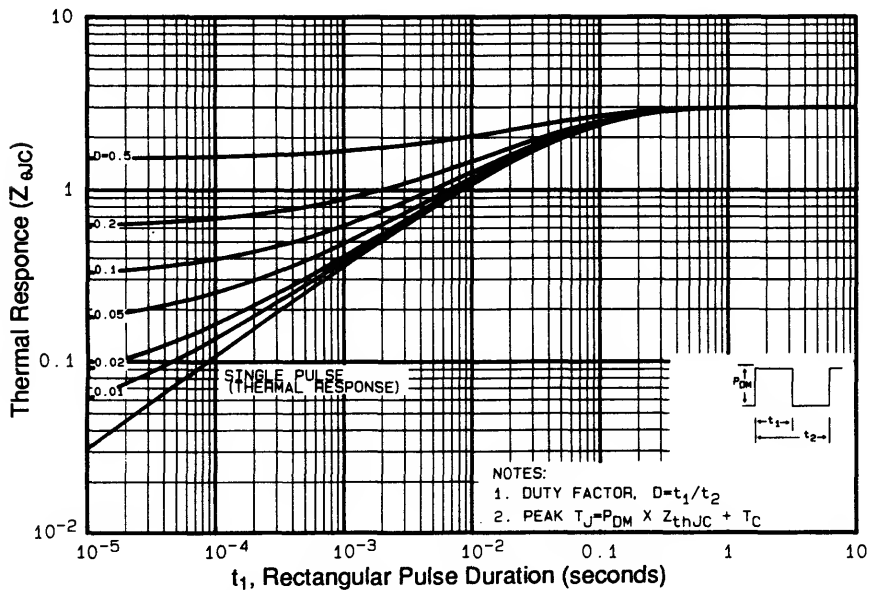
**Fig 9. Maximum Drain Current Vs. Case Temperature**



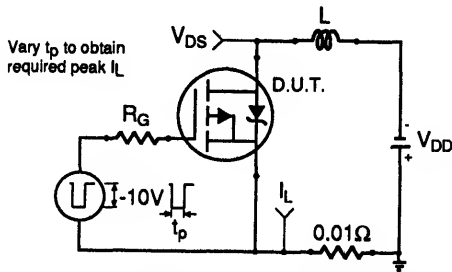
**Fig 10a. Switching Time Test Circuit**



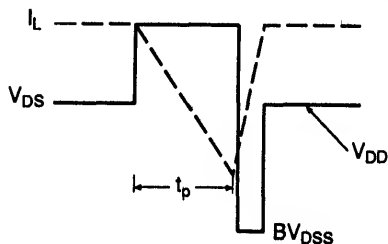
**Fig 10b. Switching Time Waveforms**



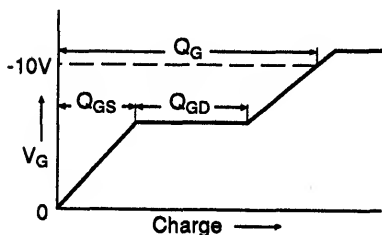
**Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case**



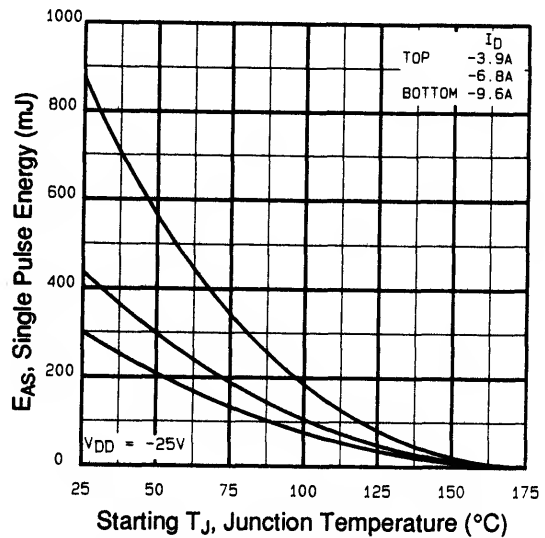
**Fig 12a. Unclamped Inductive Test Circuit**



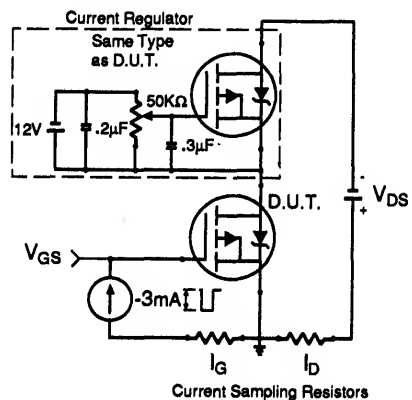
**Fig 12b. Unclamped Inductive Waveforms**



**Fig 13a. Basic Gate Charge Waveform**



**Fig 12c. Maximum Avalanche Energy vs. Drain Current**



**Fig 13b. Gate Charge Test Circuit**

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

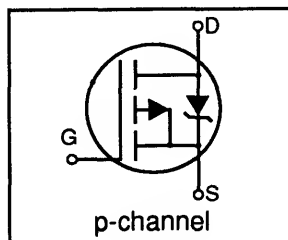
**Appendix D:** Part Marking Information

# International Rectifier

## IRFR9110 IRFU9110

### HEXFET® Power MOSFET

- Surface Mount (IRFR9110)
- Straight Lead (IRFU9110)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- P-Channel

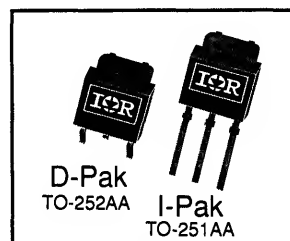


$$\begin{aligned} BV_{DSS} & -100V \\ R_{DS(on)} & 1.2\Omega \\ I_D & -3.4A \end{aligned}$$

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D @ T_C = 25^{\circ}C$	Continuous Drain Current, $V_{GS}@-10V$	-3.4	A
$I_D @ T_C = 100^{\circ}C$	Continuous Drain Current, $V_{GS}@-10V$	-2.4	
$I_{DM}$	Pulsed Drain Current ①	-14	
$P_D @ T_C = 25^{\circ}C$	Maximum Power Dissipation	30	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	-3.4	A
$E_{AR}$	Repetitive Avalanche Energy ①	3.0	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-5.5	V/ns
$T_J$	Operating Junction and	-55 to +175	$^{\circ}C$
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

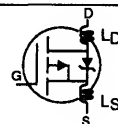
### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	



Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-100	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.091	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.2	$\Omega$	$V_{GS}=-10V$ , $I_D=-2.0A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	1.3	---	---	S	$V_{DS}=-50V$ , $I_{DS}=-2.0A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-100V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	8.7	nC	$I_D=-4.0A$ , $V_{DS}=-80V$ , $V_{GS}=-10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.2		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	4.1		
$t_{d(on)}$	Turn-On Delay Time	---	10	---	ns	$V_{DD}=-50V$ , $I_D=-4.0A$ $R_G=11\Omega$ , $R_D=24\Omega$ ④
$t_r$	Rise Time	---	27	---		
$t_{d(off)}$	Turn-Off Delay Time	---	15	---		
$t_f$	Fall Time	---	17	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	200	---	pF	$V_{GS}=0V$ , $V_{DS}=-25V$ $f=1.0Mhz$
$C_{oss}$	Output Capacitance	---	94	---		
$C_{rss}$	Reverse Transfer Capacitance	---	18	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-3.4	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-14		
$V_{SD}$	Diode Forward Voltage	---	---	-5.5	V	$T_J=25^\circ\text{C}$ , $I_S=-3.4A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	41	---	160	ns	$T_J=25^\circ\text{C}$ , $I_F=-4.0A$ , $di/dt=-100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.075	---	0.30	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=-25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=20mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-3.4A$
- ③  $I_{SD}\leq 3.4A$ ,  $di/dt\leq 75A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

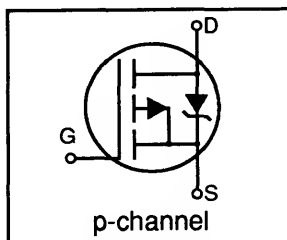
For more information on the same die in a HD-1 package refer to IRFD9110.

# International Rectifier

## IRFR9120 IRFU9120

### HEXFET® Power MOSFET

- Surface Mount (IRFR9120)
- Straight Lead (IRFU9024)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- P-Channel

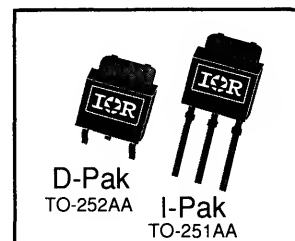


$$\begin{aligned} BV_{DSS} & -100V \\ R_{DS(on)} & 0.6\Omega \\ I_D & -6.3A \end{aligned}$$

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

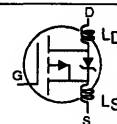
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ -10V$	-6.3	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS} @ -10V$	-4.5	
$I_{DM}$	Pulsed Drain Current ①	-25	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	50	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	270	mJ
$I_{AR}$	Avalanche Current ①	-6.3	A
$E_{AR}$	Repetitive Avalanche Energy ①	5.0	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-100	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.10	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.60	$\Omega$	$V_{GS}=-10V$ , $I_D=-3.8A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	1.7	---	---	S	$V_{DS}=-50V$ , $I_{DS}=-3.8A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-100V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	18	nC	$I_D=-6.8A$ , $V_{DS}=-80V$ , $V_{GS}=-10V$ See Fig 6 and 13④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	9.0		
$t_{d(on)}$	Turn-On Delay Time	---	9.6	---	ns	$V_{DD}=-50V$ , $I_D=-6.8A$ $R_G=18\Omega$ , $R_D=7.1\Omega$ See Fig. 10④
$t_r$	Rise Time	---	29	---		
$t_{d(off)}$	Turn-Off Delay Time	---	21	---		
$t_f$	Fall Time	---	25	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	390	---	pF	$V_{GS}=0V$ , $V_{DS}=-25V$ $f=1.0MHz$ See Fig. 5
$C_{oss}$	Output Capacitance	---	170	---		
$C_{rss}$	Reverse Transfer Capacitance	---	45	---		

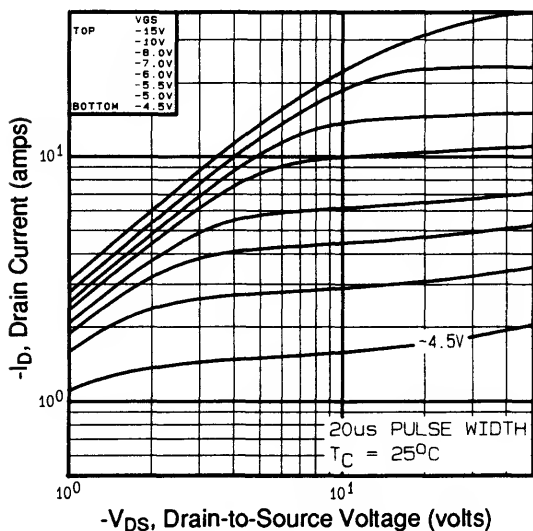


## Source-Drain Diode Ratings and Characteristics

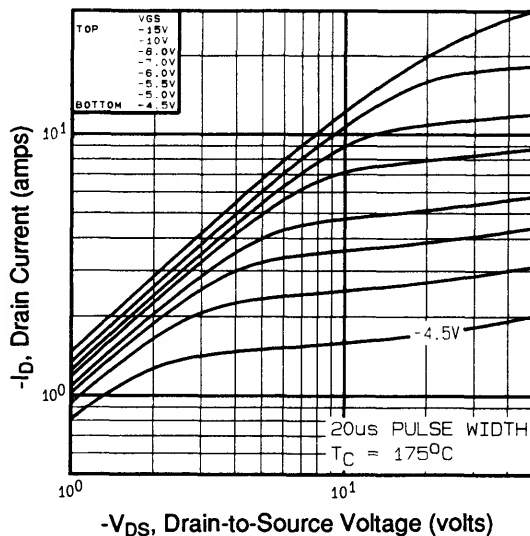
	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-6.3	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-25		
$V_{SD}$	Diode Forward Voltage	---	---	-6.3	V	$T_J=25^\circ\text{C}$ , $I_S=-6.3A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	49	---	200	ns	$T_J=25^\circ\text{C}$ , $I_F=-6.8A$ , $di/dt=-100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.17	---	0.66	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

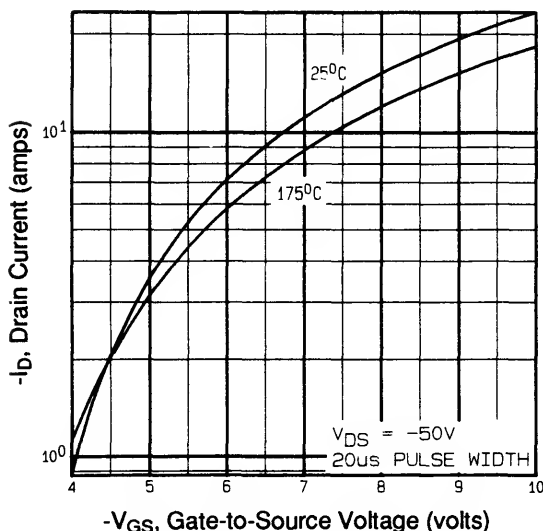
- ① Repetitive rating; Pulse width limited by max. junction temperature (See figure 11)
- ②  $V_{DD}=-25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=11mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-6.3A$  (See figure 12)
- ③  $I_{SD}\leq 6.3A$ ,  $di/dt\leq 110A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$



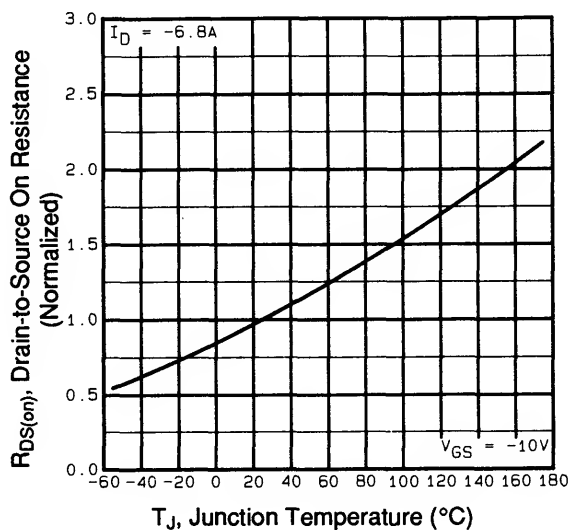
**Fig 1. Typical Output Characteristics,**  
 $T_C = 25^\circ\text{C}$



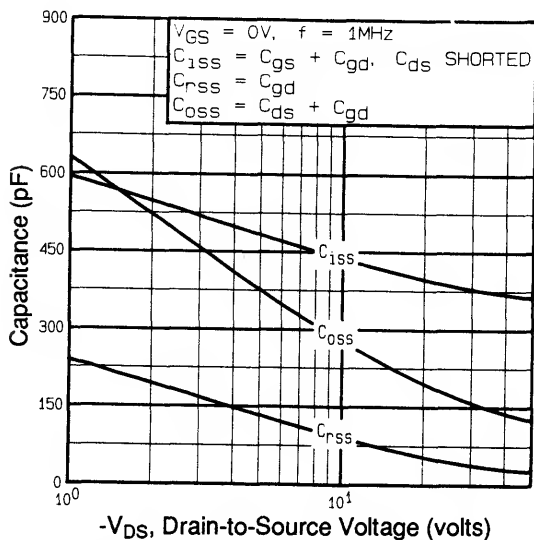
**Fig 2. Typical Output Characteristics,**  
 $T_C = 150^\circ\text{C}$



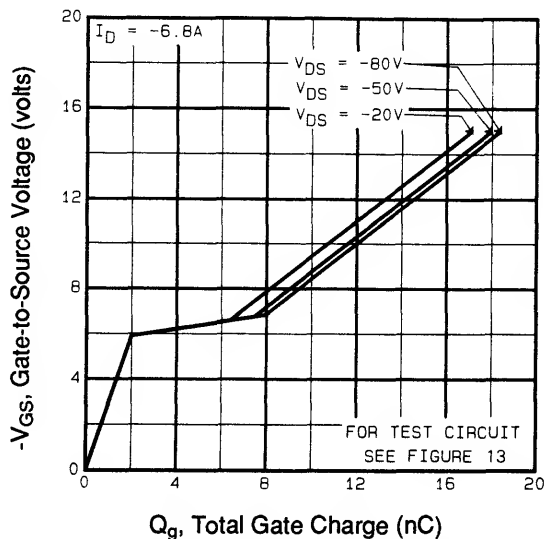
**Fig 3. Typical Transfer Characteristics**



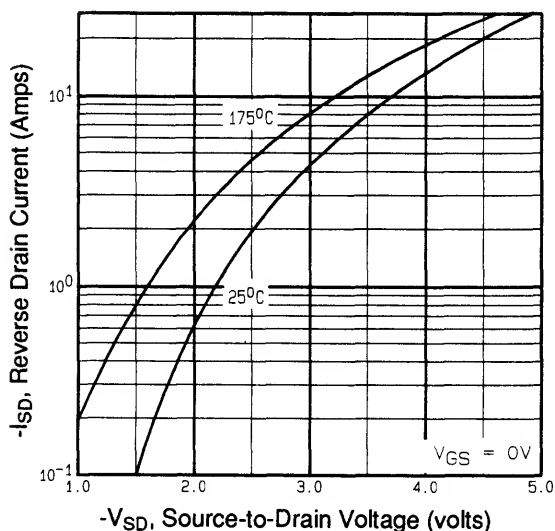
**Fig 4. Normalized On-Resistance Vs.**  
**Temperature**



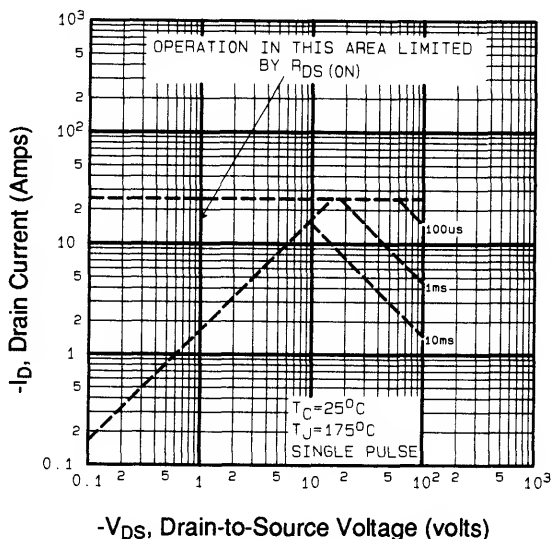
**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**



**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**



**Fig 7. Typical Source-Drain Diode Forward Voltage**



**Fig 8. Maximum Safe Operating Area**

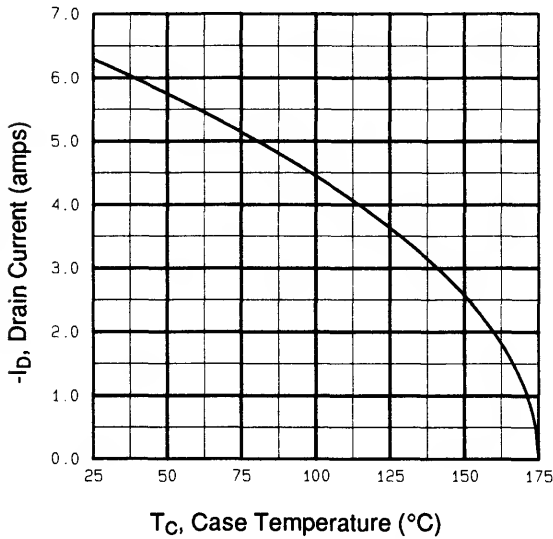


Fig 9. Maximum Drain Current Vs. Case Temperature

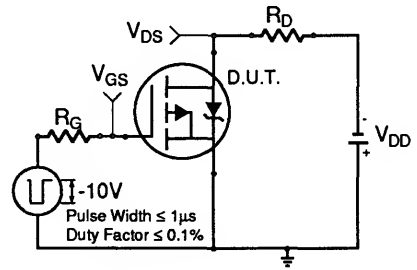


Fig 10a. Switching Time Test Circuit

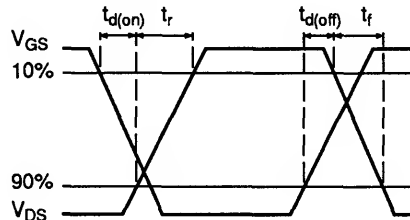


Fig 10b. Switching Time Waveforms

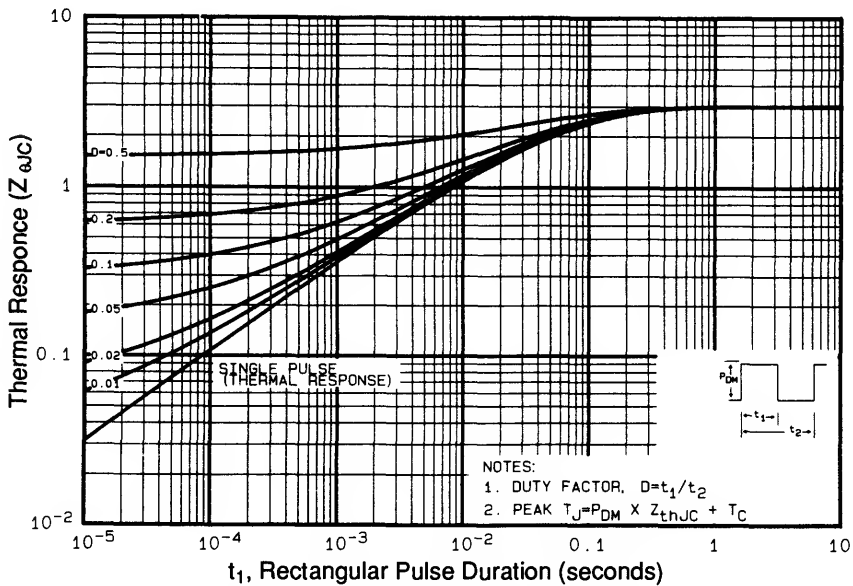
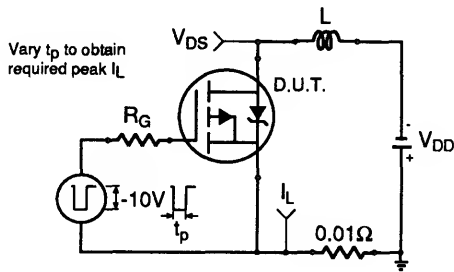
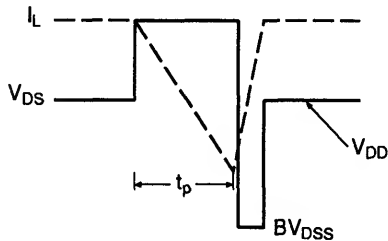


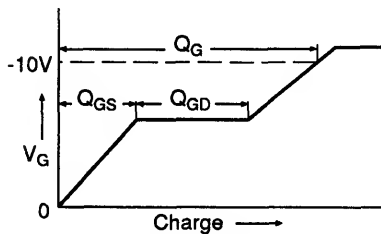
Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case



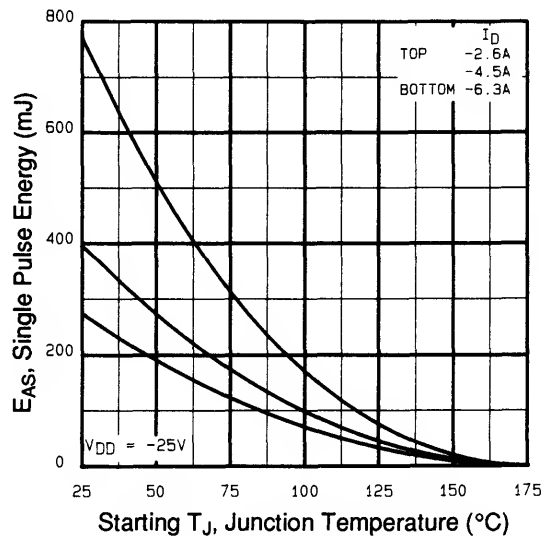
**Fig 12a.** Unclamped Inductive Test Circuit



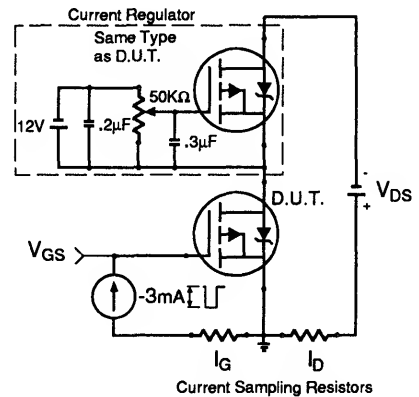
**Fig 12b.** Unclamped Inductive Waveforms



**Fig 13a.** Basic Gate Charge Waveform



**Fig 12c.** Maximum Avalanche Energy vs. Drain Current



**Fig 13b.** Gate Charge Test Circuit

**Appendix A:** Figure 14, Peak Diode Recovery  $dv/dt$  Test Circuit

**Appendix B:** Package Outline Mechanical Drawing

**Appendix C:** Tape & Reel Information

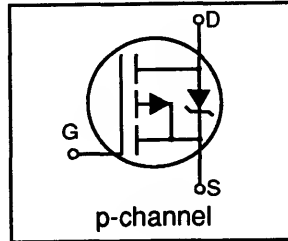
**Appendix D:** Part Marking Information

# International Rectifier

## IRFR9210 IRFU9210

### HEXFET® Power MOSFET

- Surface Mount (IRFR9210)
- Straight Lead (IRFU9210)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- P-Channel

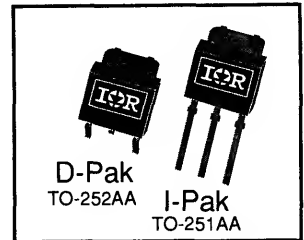


$$\begin{aligned} BV_{DS} & -200V \\ R_{DS(on)} & 3.0\Omega \\ I_D & -2.0A \end{aligned}$$

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10V$	-2.0	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10V$	-1.3	
$I_{DM}$	Pulsed Drain Current ①	-8.0	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	25	W
	Linear Derating Factor	0.20	W/K®
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	41	mJ
$I_{AR}$	Avalanche Current ①	-2.0	A
$E_{AR}$	Repetitive Avalanche Energy ①	2.5	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-5.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

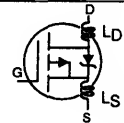
### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W®
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	



## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-200	---	---	V	$V_{GS}=0V, I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	n/a	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	3.0	$\Omega$	$V_{GS}=-10V, I_D=-1.2A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}, I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	n/a	---	---	S	$V_{DS}=-50V, I_{DS}=-1.2A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-200V, V_{GS}=0V$
		---	---	-1000		$V_{DS}=-160V, V_{GS}=0V, T_J=125^\circ\text{C}$
$IGSS$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	6.0	nC	$I_D=-2.4A, V_{DS}=-160V,$ $V_{GS}=-10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	1.2		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	3.6		
$t_{d(on)}$	Turn-On Delay Time	---	8	---	ns	$V_{DD}=-100V, I_D=-2.4A$ $R_G=24\Omega, R_D=42\Omega$ ④
$t_r$	Rise Time	---	15	---		
$t_{d(off)}$	Turn-Off Delay Time	---	10	---		
$t_f$	Fall Time	---	8	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	160	---	pF	$V_{GS}=0V, V_{DS}=-25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	50	---		
$C_{rss}$	Reverse Transfer Capacitance	---	12	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-2.0	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-8.0		
$V_{SD}$	Diode Forward Voltage	---	---	-5.8	V	$T_J=25^\circ\text{C}, I_S=-2.0A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	n/a	---	n/a	ns	$T_J=25^\circ\text{C}, I_F=-2.4A,$ $di/dt=-100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	n/a	---	n/a	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=-50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=15mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-2.0A$
- ③  $I_{SD}\leq-2.0A$ ,  $di/dt\leq-90A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

Target Data Sheet: Specification Pending; Contact Factory for Update

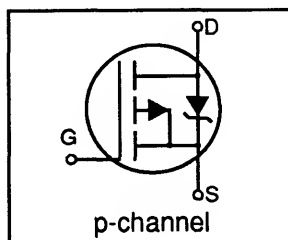
# International Rectifier

HEXFET® Power MOSFET

## IRFR9220

## IRFU9220

- Surface Mount (IRFR9220)
- Straight Lead (IRFU9220)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- P-Channel

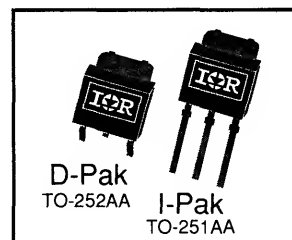


$BV_{DSS}$  -200V  
 $R_{DS(on)}$  1.5 $\Omega$   
 $I_D$  -3.6A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

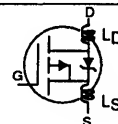
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10\text{V}$	-3.6	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@-10\text{V}$	-2.3	
$I_{DM}$	Pulsed Drain Current ①	-14	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	42	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	84	mJ
$I_{AR}$	Avalanche Current ①	-3.6	A
$E_{AR}$	Repetitive Avalanche Energy ①	4.2	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-5.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	-200	---	---	V	$V_{GS}=0V$ , $I_D=-250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	n/a	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=-1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	1.5	$\Omega$	$V_{GS}=-10V$ , $I_D=-2.2A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	---	-4.0	V	$V_{DS}=V_{GS}$ , $I_D=-250\mu A$
$g_{fs}$	Forward Transconductance	n/a	---	---	S	$V_{DS}=-50V$ , $I_{DS}=-2.2A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	-250	$\mu A$	$V_{DS}=-200V$ , $V_{GS}=0V$
		---	---	-1000		$V_{DS}=-160V$ , $V_{GS}=0V$ , $T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	-500	nA	$V_{GS}=-20V$
	Gate-to-Source Reverse Leakage	---	---	500		$V_{GS}=20V$
$Q_g$	Total Gate Charge	---	---	13	nC	$I_D=-4.0A$ , $V_{DS}=-160V$ , $V_{GS}=-10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.4		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.6		
$t_{d(on)}$	Turn-On Delay Time	---	15	---	ns	$V_{DD}=-100V$ , $I_D=-4.0A$ $R_G=18\Omega$ , $R_D=25\Omega$ ④
$t_r$	Rise Time	---	35	---		
$t_{d(off)}$	Turn-Off Delay Time	---	15	---		
$t_f$	Fall Time	---	25	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	340	---	pF	$V_{GS}=0V$ , $V_{DS}=-25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	105	---		
$C_{rss}$	Reverse Transfer Capacitance	---	25	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	-3.6	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	-14		
$V_{SD}$	Diode Forward Voltage	---	---	-6.3	V	$T_J=25^\circ\text{C}$ , $I_S=-3.6A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	n/a	---	n/a	ns	$T_J=25^\circ\text{C}$ , $I_F=-4.0A$ , $di/dt=-100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	n/a	---	n/a	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=-50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=9.7mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=-3.6A$
- ③  $I_{SD}\leq-3.6A$ ,  $di/dt\leq-90A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=24\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

Target Data Sheet: Specification Pending; Contact Factory for Update

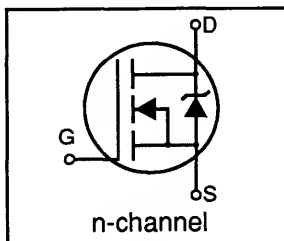
# International Rectifier

HEXFET® Power MOSFET

## IRFRC20

## IRFUC20

- Surface Mount (IRFRC20)
- Straight Lead (IRFUC20)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated

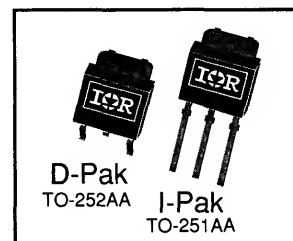


$BV_{DSS}$  600V  
 $R_{DS(on)}$  4.4Ω  
 $I_D$  2.0A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

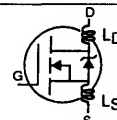
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	2.0	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	1.3	
$I_{DM}$	Pulsed Drain Current ①	8.0	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	42	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	100	mJ
$I_{AR}$	Avalanche Current ①	2.0	A
$E_{AR}$	Repetitive Avalanche Energy ①	4.2	mJ
dv/dt	Peak Diode Recovery dv/dt ③	3.0	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +150	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	600	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.88	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	4.4	$\Omega$	$V_{GS}=10V, I_D=1.2A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.0	---	---	S	$V_{DS}=100V, I_{DS}=1.2A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=600V, V_{GS}=0V$
		---	---	1000		$V_{DS}=480V, V_{GS}=0V, T_J=125^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	18	nC	$I_D=2.0A, V_{DS}=480V,$ $V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	8.9		
$t_{d(on)}$	Turn-On Delay Time	---	10	---	ns	$V_{DD}=300V, I_D=2.0A$ $R_G=18\Omega, R_D=150\Omega$ ④
$t_r$	Rise Time	---	23	---		
$t_{d(off)}$	Turn-Off Delay Time	---	30	---		
$t_f$	Fall Time	---	25	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	350	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0\text{Mhz}$
$C_{oss}$	Output Capacitance	---	48	---		
$C_{rss}$	Reverse Transfer Capacitance	---	8.6	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	2.0	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	8.0		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}, I_S=2.0A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	140	---	580	ns	$T_J=25^\circ\text{C}, I_F=2.2A,$
$Q_{RR}$	Reverse Recovery Charge	0.34	---	1.3	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

### Notes:

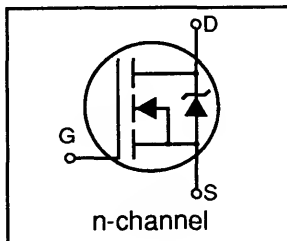
- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=50V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=49\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.0A$
- ③  $I_{SD}\leq 2.0A$ ,  $di/dt\leq 40A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 150^\circ\text{C}$  Suggested  $R_G=18\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

# International Rectifier

## IRFS1Z0

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- Surface Mount

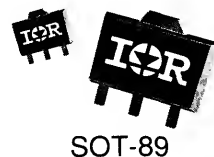


$BV_{DSS}$  100V  
 $R_{DS(on)}$  2.4 $\Omega$   
 $I_D$  0.90A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The SOT-89 package is a sub-compact surface mount case style designed for vapor phase, infra red, or wave soldering production processes. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

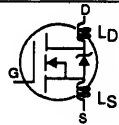
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.90	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@10\text{V}$	0.64	
$I_{DM}$	Pulsed Drain Current ①	3.6	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	4.3	W
	Linear Derating Factor	0.29	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 20$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	9.8	mJ
$I_{AR}$	Avalanche Current ③	0.90	A
$E_{AR}$	Repetitive Avalanche Energy ④	0.43	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ⑤	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	35	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	5.0	---	

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	2.4	$\Omega$	$V_{GS}=10V$ , $I_D=0.54A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	---	4.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.24	---	---	S	$V_{DS}=50V$ , $I_{DS}=0.54A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
IGSS	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=20V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-20V$
$Q_g$	Total Gate Charge	---	---	1.6	nC	$I_D=0.90A$ , $V_{DS}=80V$ , $V_{GS}=10V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	0.68		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	0.95		
$t_{d(on)}$	Turn-On Delay Time	---	7.8	---	ns	$V_{DD}=50V$ , $I_D=0.90A$ $R_G=50\Omega$ , $R_D=55\Omega$ ④
$t_r$	Rise Time	---	4.5	---		
$t_{d(off)}$	Turn-Off Delay Time	---	11	---		
$t_f$	Fall Time	---	4.7	---		
$L_D$	Internal Drain Inductance	---	2.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	3.0	---		
$C_{iss}$	Input Capacitance	---	39	---	pF	$V_{GS}=0V$ , $V_{DS}=25V$ $f=1.0\text{Mhz}$
$C_{oss}$	Output Capacitance	---	18	---		
$C_{rss}$	Reverse Transfer Capacitance	---	2.8	---		


**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	0.9	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	3.6		
$V_{SD}$	Diode Forward Voltage	---	---	1.4	V	$T_J=25^\circ\text{C}$ , $I_S=0.9A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	42	---	71	ns	$T_J=25^\circ\text{C}$ , $I_F=0.9A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.14	---	0.41	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=16\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=1.0A$
- ③  $I_{SD}\leq 0.9A$ ,  $di/dt\leq 25A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=50\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

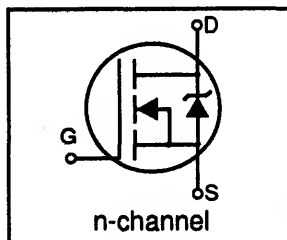
For more information on the same die in a HD-1 package refer to IRFD1Z0.

# International Rectifier

# IRLD014

## HEXFET® Power MOSFET

- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- Logic Level Gate

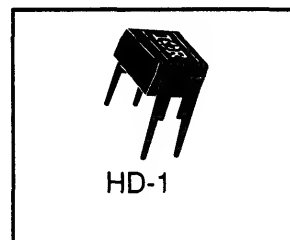


$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.20 $\Omega$   
 $I_D$  1.7A

## Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



## Absolute Maximum Ratings

Absolute Maximum Ratings			
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^{\circ}\text{C}$	Continuous Drain Current, $V_{GS}@5V$	1.7	A
$I_D$ @ $T_C = 100^{\circ}\text{C}$	Continuous Drain Current, $V_{GS}@5V$	1.2	
$I_{DM}$	Pulsed Drain Current ①	14	
$P_D$ @ $T_C = 25^{\circ}\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	130	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	4.5	V/ns
$T_J$	Operating Junction and	-55 to +175	$^{\circ}\text{C}$
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

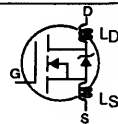
## Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W②



**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.070	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.20	$\Omega$	$V_{GS}=5.0V, I_D=1.0A$ ④
		---	---	0.28		$V_{GS}=4.0V, I_D=0.85A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.0	---	---	S	$V_{DS}=25V, I_{DS}=1.0A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V, V_{GS}=0V$
		---	---	1000		$V_{DS}=48V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	8.4	nC	$I_D=10A, V_{DS}=48V, V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.6		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	6.4		
$t_{d(on)}$	Turn-On Delay Time	---	9.3	---	ns	$V_{DD}=30V, I_D=10A$ $R_G=12\Omega, R_D=2.8\Omega$ ④
$t_r$	Rise Time	---	110	---		
$t_{d(off)}$	Turn-Off Delay Time	---	17	---		
$t_f$	Fall Time	---	26	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	400	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0\text{MHz}$
$C_{oss}$	Output Capacitance	---	170	---		
$C_{rss}$	Reverse Transfer Capacitance	---	42	---		


**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	1.7	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	14		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}, I_S=1.7A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	73	---	130	ns	$T_J=25^\circ\text{C}, I_F=10A,$
$Q_{RR}$	Reverse Recovery Charge	0.10	---	0.65	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

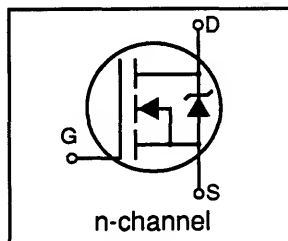
- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=55\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=1.7A$
- ③  $I_{SD}\leq 10A$ ,  $di/dt\leq 90A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=12\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C/W}$

# International Rectifier

# IRLD024

## HEXFET® Power MOSFET

- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- Logic Level Gate



$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.10 $\Omega$   
 $I_D$  2.5A

## Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1

## Absolute Maximum Ratings

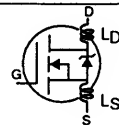
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^{\circ}\text{C}$	Continuous Drain Current, $V_{GS}@5V$	2.5	A
$I_D$ @ $T_C = 100^{\circ}\text{C}$	Continuous Drain Current, $V_{GS}@5V$	1.8	
$I_{DM}$	Pulsed Drain Current ①	20	
$P_D@T_C = 25^{\circ}\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K②
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	91	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^{\circ}\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

## Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W④

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.060	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.10	$\Omega$	$V_{GS}=5.0V, I_D=1.5A$ ④
		---	---	0.14		$V_{GS}=4.0V, I_D=1.3A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	1.4	---	---	S	$V_{DS}=25V, I_{DS}=1.5A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V, V_{GS}=0V$
		---	---	1000		$V_{DS}=48V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	18	nC	$I_D=16A, V_{DS}=48V, V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	4.5		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	12		
$t_{d(on)}$	Turn-On Delay Time	---	11	---	ns	$V_{DD}=30V, I_D=16A$ $R_G=9.0\Omega, R_D=1.7\Omega$ ④
$t_r$	Rise Time	---	110	---		
$t_{d(off)}$	Turn-Off Delay Time	---	23	---		
$t_f$	Fall Time	---	41	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	880	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	350	---		
$C_{rss}$	Reverse Transfer Capacitance	---	54	---		


**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	2.5	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	20		
$V_{SD}$	Diode Forward Voltage	---	---	1.5	V	$T_J=25^\circ\text{C}, I_S=2.5A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	70	---	140	ns	$T_J=25^\circ\text{C}, I_F=16A, di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.19	---	0.78	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=17.5mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.5A$
- ③  $I_{SD}\leq 17A$ ,  $di/dt\leq 140A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=9.0\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

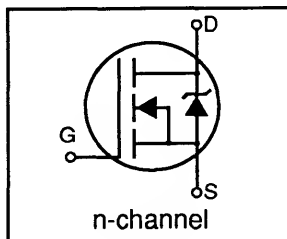
For more information on the same die in a TO-220 package refer to IRLZ24.

# International Rectifier

## IRLD110

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- Logic Level Gate



$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.54 $\Omega$   
 $I_D$  1.0A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1

### Absolute Maximum Ratings

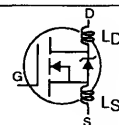
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	1.0	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	0.70	
$I_{DM}$	Pulsed Drain Current ①	8.0	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	140	mJ
$I_{AR}$	Avalanche Current ①	1.0	A
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.5	V/ns
$T_J$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
$T_{STG}$	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W⑥

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V$ , $I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	$V/^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.54	$\Omega$	$V_{GS}=5.0V$ , $I_D=0.6A$ ④
		---	---	0.76		$V_{GS}=4.0V$ , $I_D=0.50A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}$ , $I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.8	---	---	S	$V_{DS}=50V$ , $I_{DS}=0.60A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V$ , $V_{GS}=0V$
		---	---	1000		$V_{DS}=80V$ , $V_{GS}=0V$ , $T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	6.1	nC	$I_D=5.6A$ , $V_{DS}=80V$ , $V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.6		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	3.3		
$t_{d(on)}$	Turn-On Delay Time	---	9.3	---	ns	$V_{DD}=50V$ , $I_D=5.6A$ $R_G=12\Omega$ , $R_D=8.4\Omega$ ④
$t_r$	Rise Time	---	47	---		
$t_{d(off)}$	Turn-Off Delay Time	---	16	---		
$t_f$	Fall Time	---	17	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	250	---	pF	$V_{GS}=0V$ , $V_{DS}=25v$ $f=1.0\text{Mhz}$
$C_{oss}$	Output Capacitance	---	80	---		
$C_{rss}$	Reverse Transfer Capacitance	---	15	---		


**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	5.6	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	18		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}$ , $I_S=1.0A$ , $V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	89	---	130	ns	$T_J=25^\circ\text{C}$ , $I_F=5.6A$ , $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.35	---	0.65	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

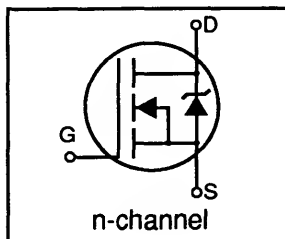
- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=52\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.0A$
- ③  $I_{SD}\leq 5.6A$ ,  $di/dt\leq 75A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=12\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

# International Rectifier

## IRLD120

### HEXFET® Power MOSFET

- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- For Automatic Insertion
- End Stackable
- Logic Level Gate



$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.27 $\Omega$   
 $I_D$  1.3A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The 4-pin DIP package is a low cost machine insertable case style which can be stacked in multiple combinations on standard 0.1 inch pin centers. The dual drain pin serves as a thermal link to the mounting surface for power dissipation levels up to 1 watt.



HD-1

### Absolute Maximum Ratings

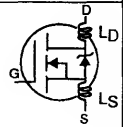
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5\text{V}$	1.3	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5\text{V}$	0.94	
$I_{DM}$	Pulsed Drain Current ①	10	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	1.3	W
	Linear Derating Factor	0.0083	W/K®
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	100	mJ
$I_{AR}$	Avalanche Current ①	1.3	V
$E_{AR}$	Repetitive Avalanche Energy ①	0.13	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Max.	Units
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	120	K/W®

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1\text{mA}$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.27	$\Omega$	$V_{GS}=5.0V, I_D=0.78A$ ④
		---	---	0.38		$V_{GS}=4.0V, I_D=0.65A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	0.92	---	---	S	$V_{DS}=50V, I_{DS}=0.78A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V, V_{GS}=0V$
		---	---	1000		$V_{DS}=80V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	12	nC	$I_D=9.2A, V_{DS}=80V, V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.1		
$t_{d(on)}$	Turn-On Delay Time	---	9.8	---	ns	$V_{DD}=50V, I_D=9.2A$ $R_G=9.0\Omega, R_D=5.2\Omega$ ④
$t_r$	Rise Time	---	64	---		
$t_{d(off)}$	Turn-Off Delay Time	---	21	---		
$t_f$	Fall Time	---	27	---		
$L_D$	Internal Drain Inductance	---	4.0	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	6.0	---		
$C_{iss}$	Input Capacitance	---	490	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0\text{MHz}$
$C_{oss}$	Output Capacitance	---	150	---		
$C_{rss}$	Reverse Transfer Capacitance	---	30	---		


**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	1.3	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	10		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}, I_S=1.3A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	82	---	140	ns	$T_J=25^\circ\text{C}, I_F=9.2A,$
$Q_{RR}$	Reverse Recovery Charge	0.64	---	1.0	$\mu C$	$di/dt=100A/\mu S$ ④
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

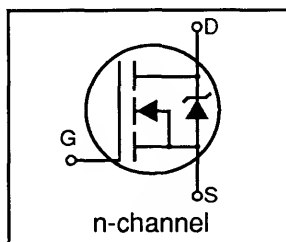
- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=24\text{mH}$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=2.6A$
- ③  $I_{SD}\leq 9.2A$ ,  $di/dt\leq 110A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=9.0\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

# International Rectifier

## IRLR014 IRLU014

HEXFET® Power MOSFET

- Surface Mount (IRLR014)
- Straight Lead (IRLU014)
- Dynamic  $dv/dt$  Rated
- Logic Level Gate

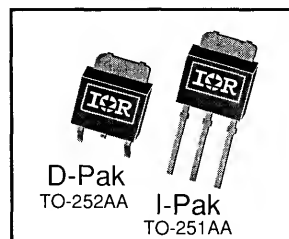


$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.20 $\Omega$   
 $I_D$  8.5A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	8.5	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	6.0	
$I_{DM}$	Pulsed Drain Current ①	31	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	30	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	47	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

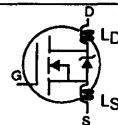
### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	



Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.070	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.20	$\Omega$	$V_{GS}=5.0V, I_D=5.1A$ ④
		---	---	0.28		$V_{GS}=4.0V, I_D=4.3A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	3.7	---	---	S	$V_{DS}=25V, I_{DS}=5.1A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V, V_{GS}=0V$
		---	---	1000		$V_{DS}=48V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	8.4	nC	$I_D=10A, V_{DS}=48V, V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.6		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	6.4		
$t_{d(on)}$	Turn-On Delay Time	---	9.3	---	ns	$V_{DD}=30V, I_D=10A$ $R_G=12\Omega, R_D=2.8\Omega$ ④
$t_r$	Rise Time	---	110	---		
$t_{d(off)}$	Turn-Off Delay Time	---	17	---		
$t_f$	Fall Time	---	26	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	400	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	170	---		
$C_{rss}$	Reverse Transfer Capacitance	---	42	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	8.5	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	31		
$V_{SD}$	Diode Forward Voltage	---	---	1.6	V	$T_J=25^\circ\text{C}, I_S=8.5A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	73	---	130	ns	$T_J=25^\circ\text{C}, I_F=10A,$ $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.10	---	0.65	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

① Repetitive rating; Pulse width limited by max. junction temperature

③  $I_{SD} \leq 8.5A$ ,  $di/dt \leq 90A/\mu s$ ,  $V_{DD} \leq BV_{DSS}$ ,  
 $T_J \leq 175^\circ\text{C}$  Suggested  $R_G=12\Omega$ ⑤ Mounting surface:  
flat, smooth, greased②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=850\mu H$ ,  
 $R_G=25\Omega$ , Peak  $I_{AS}=8.5A$ ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$ ⑥  $K/W = ^\circ C/W$

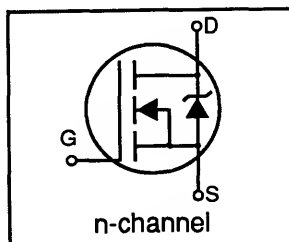
# International Rectifier

## IRLR024

## IRLU024

### HEXFET® Power MOSFET

- Surface Mount (IRLR024)
- Straight Lead (IRLU024)
- Dynamic  $dv/dt$  Rated
- Logic Level Gate

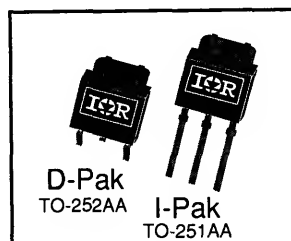


$BV_{DSS}$  60V  
 $R_{DS(on)}$  0.10 $\Omega$   
 $I_D$  16A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

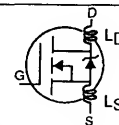
	Parameter	Max.	Units
$I_D @ T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	16	A
$I_D @ T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	11	
$I_{DM}$	Pulsed Drain Current ①	64	
$P_D @ T_C = 25^\circ\text{C}$	Maximum Power Dissipation	50	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	91	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	4.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

**Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	60	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.060	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.10	$\Omega$	$V_{GS}=5.0V, I_D=9.6A$ ④
		---	---	0.14		$V_{GS}=4.0V, I_D=8.0A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	7.9	---	---	S	$V_{DS}=25V, I_{DS}=9.6A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=60V, V_{GS}=0V$
		---	---	1000		$V_{DS}=48V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	18	nC	$I_D=16A, V_{DS}=48V, V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	4.5		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	12		
$t_{d(on)}$	Turn-On Delay Time	---	11	---	ns	$V_{DD}=30V, I_D=16A$ $R_G=9.0\Omega, R_D=1.7\Omega$ ④
$t_r$	Rise Time	---	110	---		
$t_{d(off)}$	Turn-Off Delay Time	---	23	---		
$t_f$	Fall Time	---	41	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	880	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	350	---		
$C_{rss}$	Reverse Transfer Capacitance	---	54	---		


**Source-Drain Diode Ratings and Characteristics**

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	16	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	64		
$V_{SD}$	Diode Forward Voltage	---	---	1.5	V	$T_J=25^\circ\text{C}, I_S=16A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	70	---	140	ns	$T_J=25^\circ\text{C}, I_F=16A, di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.19	---	0.78	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

**Notes:**

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=450\mu H$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=16A$
- ③  $I_{SD}\leq 16A$ ,  $di/dt\leq 140A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=9.0\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ C/W$

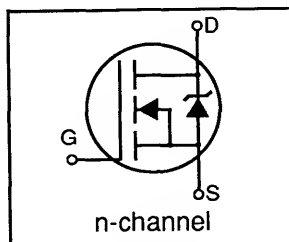
For more information on the same die in a TO-220 package refer to IRLZ24.

# International Rectifier

## IRLR110 IRLU110

HEXFET® Power MOSFET

- Surface Mount (IRLR110)
- Straight Lead (IRLU110)
- Repetitive Avalanche Rated
- Dynamic dv/dt Rated
- Logic Level Gate

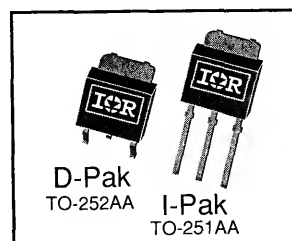


$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.54 $\Omega$   
 $I_D$  4.6A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

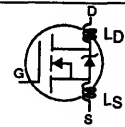
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	4.6	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5V$	3.3	
$I_{DM}$	Pulsed Drain Current ①	18	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	30	W
	Linear Derating Factor	0.20	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	100	mJ
$I_{AR}$	Avalanche Current ①	4.6	A
$E_{AR}$	Repetitive Avalanche Energy ①	3.0	mJ
dv/dt	Peak Diode Recovery dv/dt ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	5.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.54	$\Omega$	$V_{GS}=5.0V, I_D=2.7A$ ④
		---	---	0.76		$V_{GS}=4.0V, I_D=2.3A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	2.3	---	---	S	$V_{DS}=50V, I_{DS}=2.7A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V, V_{GS}=0V$
		---	---	1000		$V_{DS}=80V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	6.1	nC	$I_D=5.6A, V_{DS}=80V, V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	2.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	3.3		
$t_{d(on)}$	Turn-On Delay Time	---	9.3	---	ns	$V_{DD}=50V, I_D=5.6A$ $R_G=12\Omega, R_D=8.4\Omega$ ④
$t_r$	Rise Time	---	47	---		
$t_{d(off)}$	Turn-Off Delay Time	---	16	---		
$t_f$	Fall Time	---	17	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	250	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	80	---		
$C_{rss}$	Reverse Transfer Capacitance	---	15	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	4.6	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	18		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}, I_S=4.6A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	89	---	130	ns	$T_J=25^\circ\text{C}, I_F=5.6A,$ $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.35	---	0.65	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

- ① Repetitive rating; Pulse width limited by max. junction temperature
- ②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=7.4mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=4.6A$
- ③  $I_{SD}\leq 4.6A$ ,  $di/dt\leq 75A/\mu s$ ,  $V_{DD}\leq BV_{DSS}$ ,  $T_J\leq 175^\circ\text{C}$  Suggested  $R_G=12\Omega$
- ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$
- ⑤ Mounting surface: flat, smooth, greased
- ⑥  $K/W = ^\circ\text{C}/W$

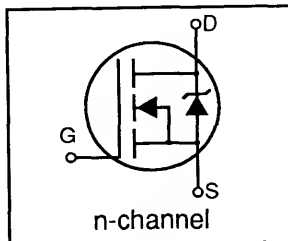
# International Rectifier

HEXFET® Power MOSFET

## IRLR120

## IRLU120

- Surface Mount (IRLR120)
- Straight Lead (IRLU120)
- Repetitive Avalanche Rated
- Dynamic  $dv/dt$  Rated
- Logic Level Gate

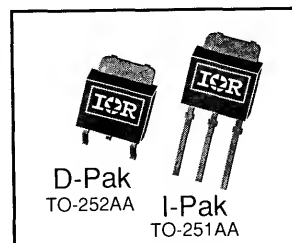


$BV_{DSS}$  100V  
 $R_{DS(on)}$  0.27 $\Omega$   
 $I_D$  8.4A

### Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching speed, ruggedized device design, and low on resistance.

The D-Pak is designed for surface mounting using vapor phase, infra red, or wave soldering techniques. The straight lead version (IRFU series) is for through hole mounting applications. Power dissipation levels up to 2 watts are possible in SMD applications.



### Absolute Maximum Ratings

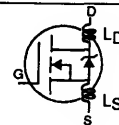
	Parameter	Max.	Units
$I_D$ @ $T_C = 25^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5\text{V}$	8.4	A
$I_D$ @ $T_C = 100^\circ\text{C}$	Continuous Drain Current, $V_{GS}@5\text{V}$	5.9	
$I_{DM}$	Pulsed Drain Current ①	31	
$P_D$ @ $T_C = 25^\circ\text{C}$	Maximum Power Dissipation	50	W
	Linear Derating Factor	0.33	W/K⑥
$V_{GS}$	Gate-to-Source Breakdown Voltage	$\pm 10$	V
$E_{AS}$	Single Pulse Avalanche Energy ②	210	mJ
$I_{AR}$	Avalanche Current ①	8.4	A
$E_{AR}$	Repetitive Avalanche Energy ①	5.0	mJ
$dv/dt$	Peak Diode Recovery $dv/dt$ ③	5.5	V/ns
$T_J$ $T_{STG}$	Operating Junction and Storage Temperature Range	-55 to +175	$^\circ\text{C}$
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

### Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	---	3.0	K/W⑥
$R_{\theta CS}$	Case-to-Sink ⑤	---	1.7	---	
$R_{\theta JA}$	Junction-to-Ambient, Typical Socket Mount	---	---	110	

Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$BV_{DSS}$	Drain-to-Source Breakdown Voltage	100	---	---	V	$V_{GS}=0V, I_D=250\mu A$
$\Delta BV_{DSS}/\Delta T_J$	Temp. Coefficient of Breakdown Voltage	---	0.12	---	V/ $^\circ\text{C}$	Reference to $25^\circ\text{C}$ , $I_D=1mA$
$R_{DS(on)}$	Static Drain-to-Source On Resistance	---	---	0.27	$\Omega$	$V_{GS}=5.0V, I_D=5.0A$ ④
		---	---	0.38		$V_{GS}=4.0V, I_D=4.2A$ ④
$V_{GS(th)}$	Gate Threshold Voltage	1.0	---	2.0	V	$V_{DS}=V_{GS}, I_D=250\mu A$
$g_{fs}$	Forward Transconductance	4.8	---	---	S	$V_{DS}=50V, I_{DS}=5.0A$ ④
$I_{DSS}$	Zero Gate Voltage Collector Current	---	---	250	$\mu A$	$V_{DS}=100V, V_{GS}=0V$
		---	---	1000		$V_{DS}=80V, V_{GS}=0V, T_J=150^\circ\text{C}$
$I_{GSS}$	Gate-to-Source Forward Leakage	---	---	500	nA	$V_{GS}=10V$
	Gate-to-Source Reverse Leakage	---	---	-500		$V_{GS}=-10V$
$Q_g$	Total Gate Charge	---	---	12	nC	$I_D=9.2A, V_{DS}=80V, V_{GS}=5.0V$ ④
$Q_{gs}$	Gate-to-Source Charge	---	---	3.0		
$Q_{gd}$	Gate-to-Drain ("Miller") Charge	---	---	7.1		
$t_{d(on)}$	Turn-On Delay Time	---	9.8	---	ns	$V_{DD}=50V, I_D=9.2A$ $R_G=9.0\Omega, R_D=5.2\Omega$ ④
$t_r$	Rise Time	---	64	---		
$t_{d(off)}$	Turn-Off Delay Time	---	21	---		
$t_f$	Fall Time	---	27	---		
$L_D$	Internal Drain Inductance	---	4.5	---	nH	Between lead, 6mm (0.25in.) from package, and center of die contact.
$L_S$	Internal Source Inductance	---	7.5	---		
$C_{iss}$	Input Capacitance	---	490	---	pF	$V_{GS}=0V, V_{DS}=25V$ $f=1.0MHz$
$C_{oss}$	Output Capacitance	---	150	---		
$C_{rss}$	Reverse Transfer Capacitance	---	30	---		



## Source-Drain Diode Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_S$	Continuous Source Current (Body Diode)	---	---	8.4	A	MOSFET symbol showing the integral reverse p-n junction diode.
$I_{SM}$	Pulsed Source Current (Body Diode) ①	---	---	31		
$V_{SD}$	Diode Forward Voltage	---	---	2.5	V	$T_J=25^\circ\text{C}, I_S=8.4A, V_{GS}=0V$ ④
$t_{rr}$	Reverse Recovery Time	82	---	140	ns	$T_J=25^\circ\text{C}, I_F=9.2A,$ $di/dt=100A/\mu S$ ④
$Q_{RR}$	Reverse Recovery Charge	0.64	---	1.0	$\mu C$	
$t_{on}$	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S + L_D$ )				

## Notes:

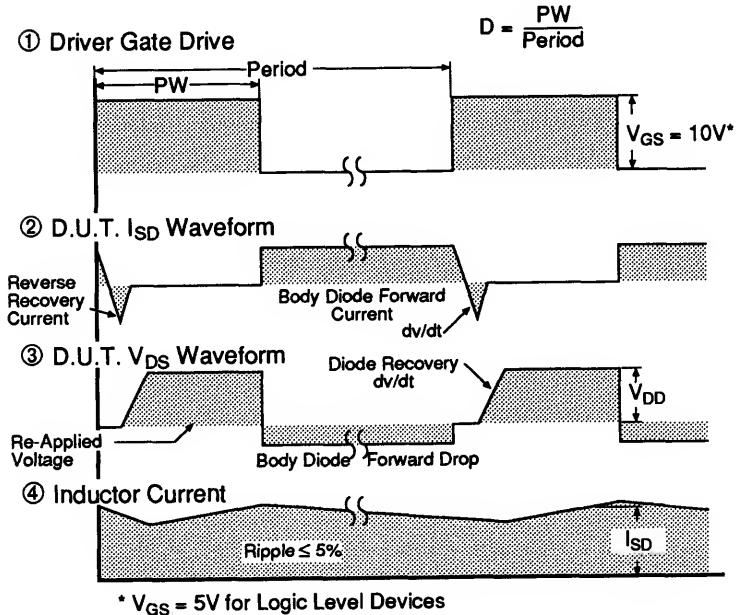
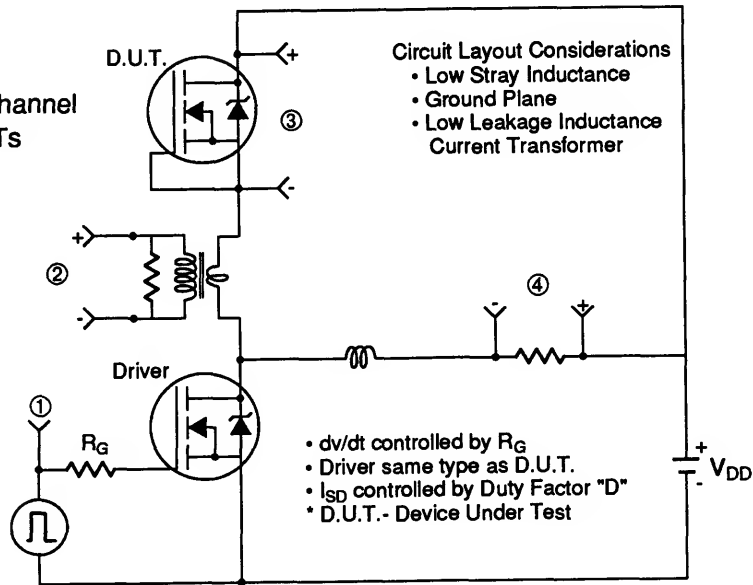
① Repetitive rating; Pulse width limited by max. junction temperature

③  $I_{SD} \leq 8.4A, di/dt \leq 110A/\mu s, V_{DD} \leq BV_{DSS}, T_J \leq 175^\circ\text{C}$  Suggested  $R_G=9.0\Omega$ 

⑤ Mounting surface: flat, smooth, greased

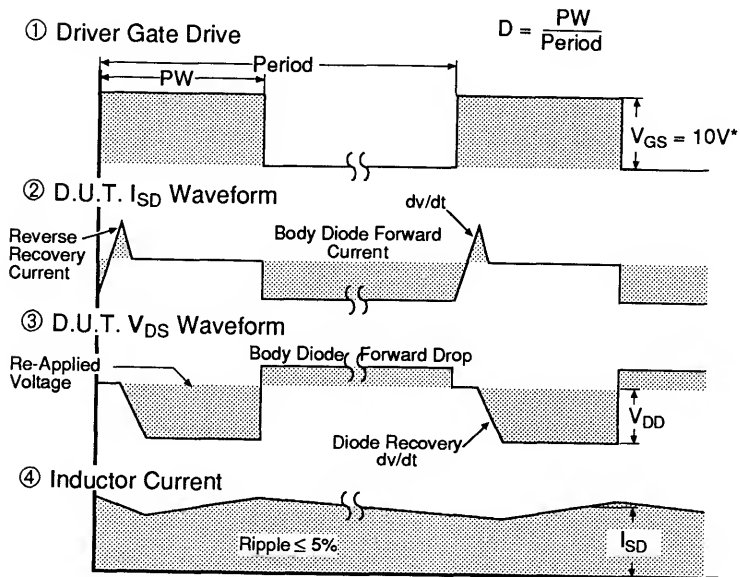
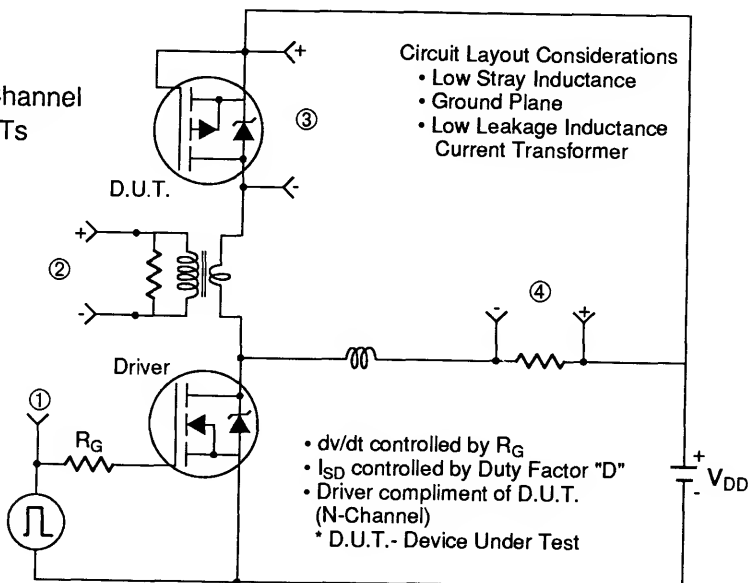
②  $V_{DD}=25V$ , Starting  $T_J=25^\circ\text{C}$ ,  $L=4.4mH$ ,  $R_G=25\Omega$ , Peak  $I_{AS}=8.4A$ ④ Pulse width  $\leq 300\mu s$ ; duty Cycle  $\leq 2\%$ ⑥  $K/W = ^\circ\text{C/W}$

**Fig 14.** For N-Channel HEXFETs





**Fig 14.** For P-Channel HEXFETs



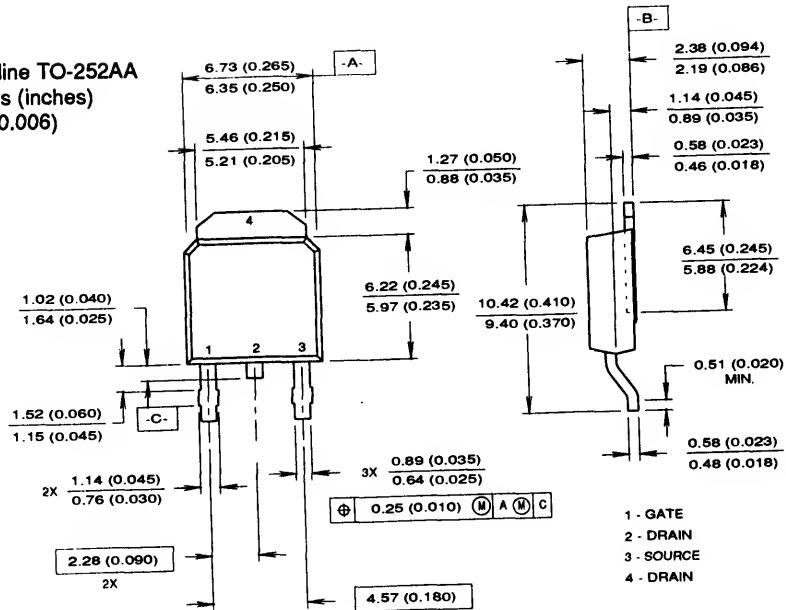
\*  $V_{GS} = 5V$  for Logic Level Devices

## TO-252AA Outline

Conforms to JEDEC outline TO-252AA

Dimensions in millimeters (inches)

Solder dip max. + 0.16 (0.006)

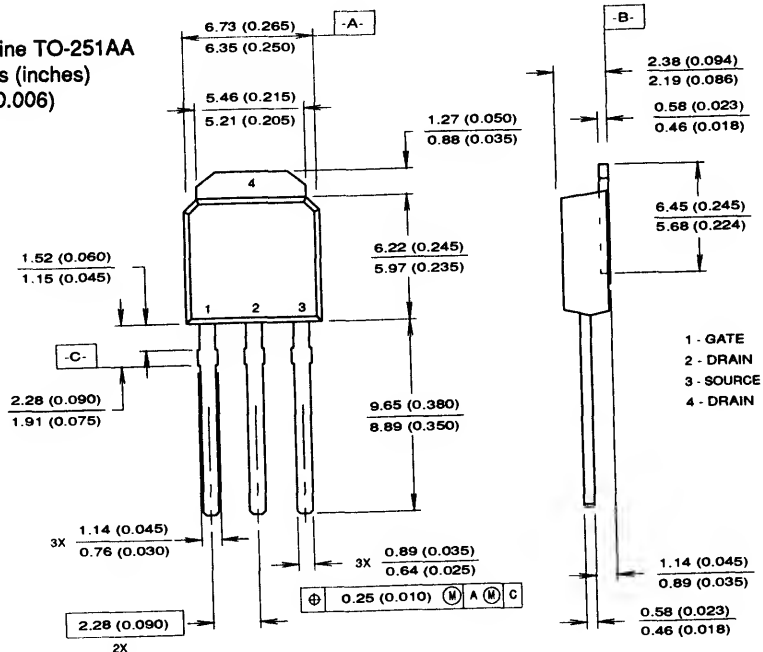


## TO-251AA Outline

Conforms to JEDEC outline TO-251AA

Dimensions in millimeters (inches)

Solder dip max. + 0.16 (0.006)



# Appendix B

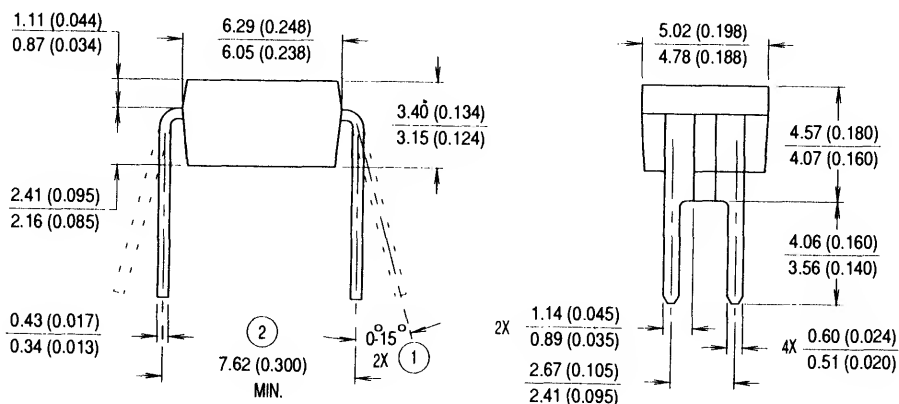
## Package Outline

### HD-1 Outline

Similar to JEDEC outline MO-001  
Dimensions in millimeters (inches)

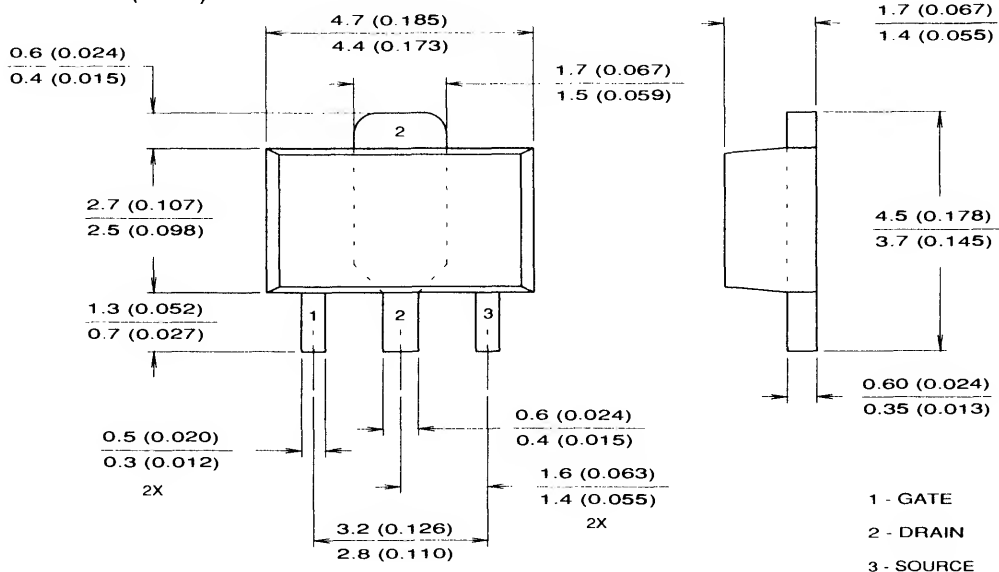


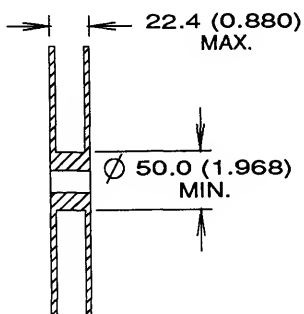
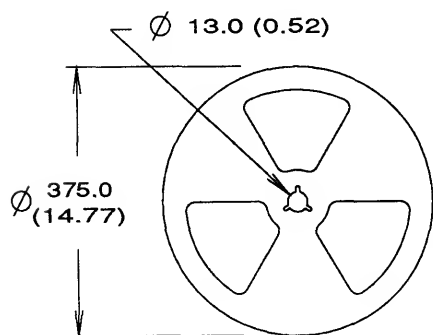
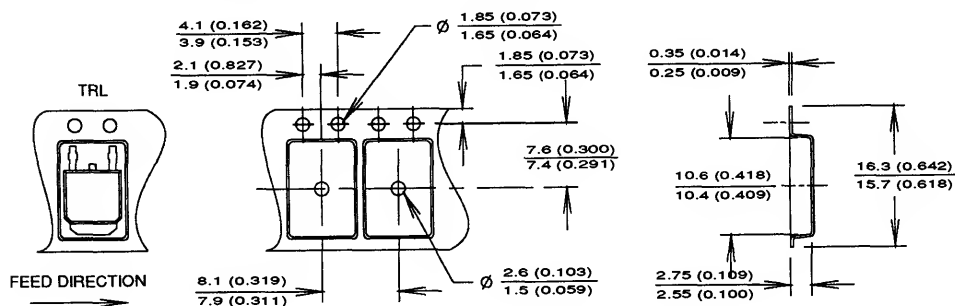
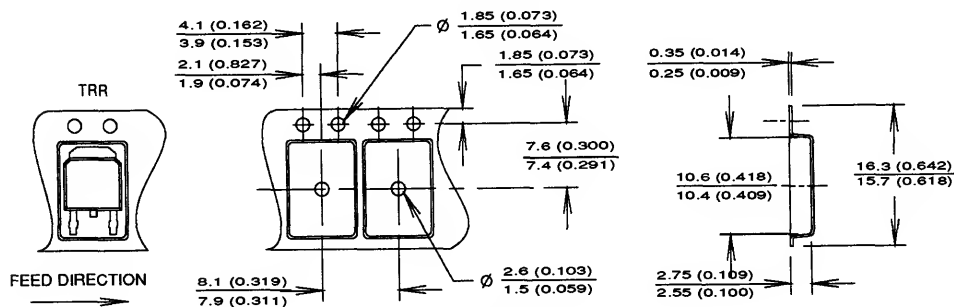
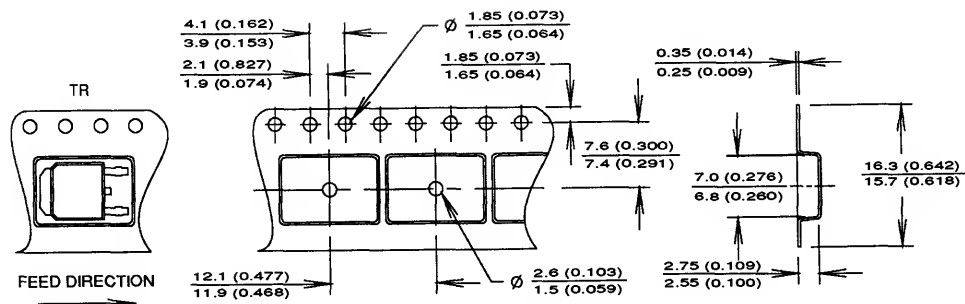
- ① APPLIES TO SPREAD OF LEADS PRIOR TO INSTALLATION
- ② APPLIES TO INSTALLED LEAD CENTERS



### SOT-89 Outline

Dimensions in millimeters (inches)

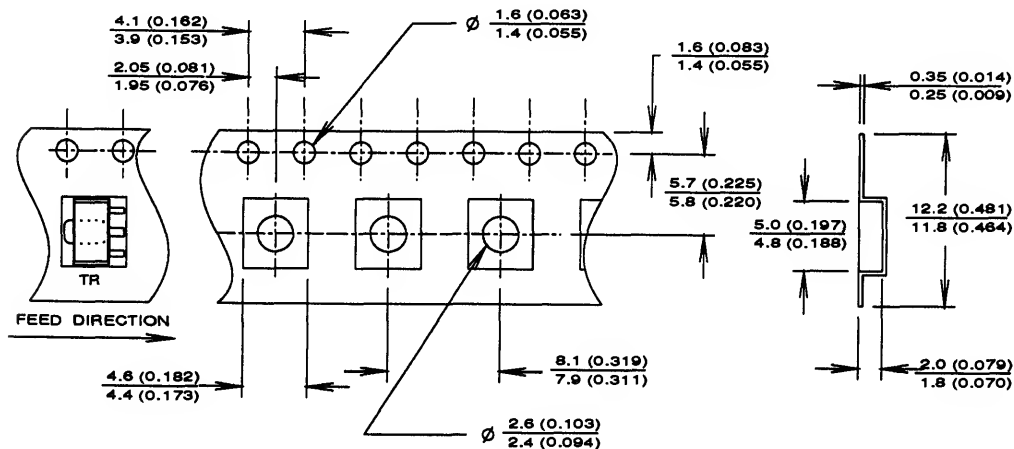
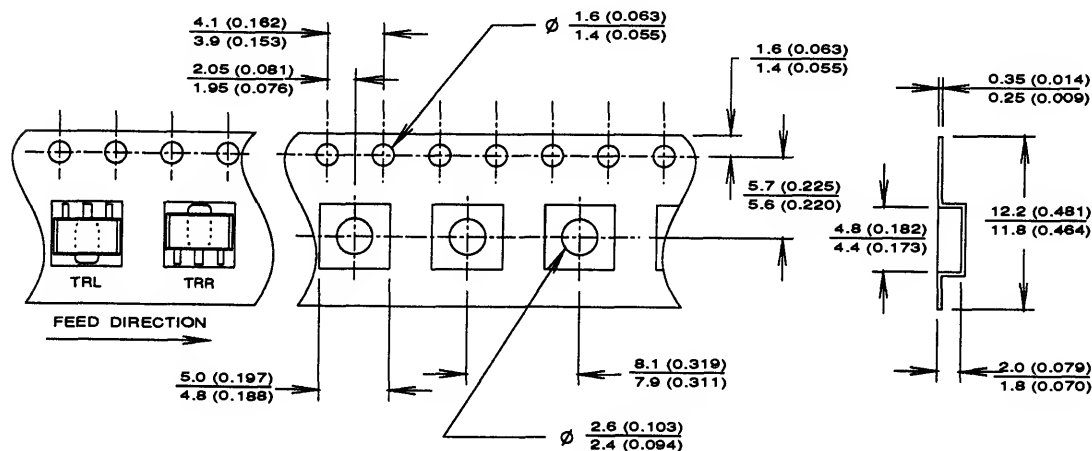




## TO-252AA Tape &amp; Reel

When ordering, indicate the part number, part orientation, and the quantity. Quantities are in multiples of 2,000 pieces per reel for TR and multiples of 3,000 pieces per reel for both TRR and TRL.

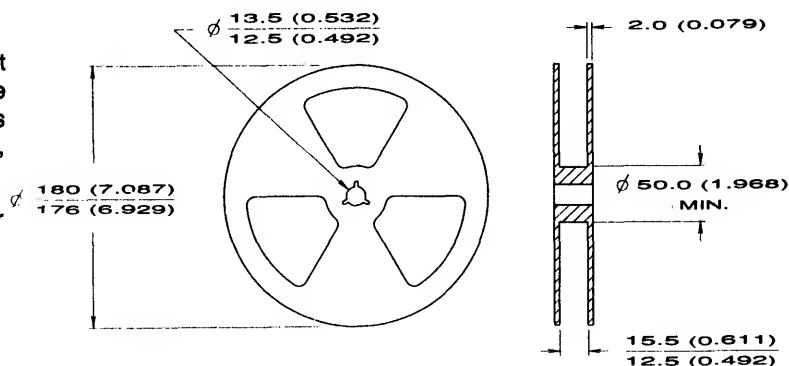
e.g., IRFR9014 TRL three-reel order is 9,000 pieces.



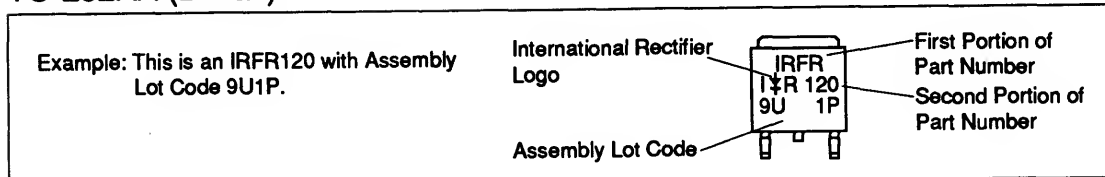
### SOT-89 Tape & Reel

When ordering, indicate the part number, part orientation, and the quantity. Quantities are in multiples of 1,000 pieces per reel for TR, TRL, and TRR.

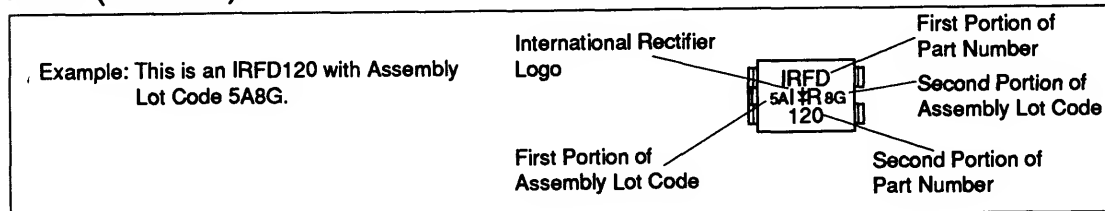
e.g., IRFS120 TRL three-reel order is 3,000 pieces.



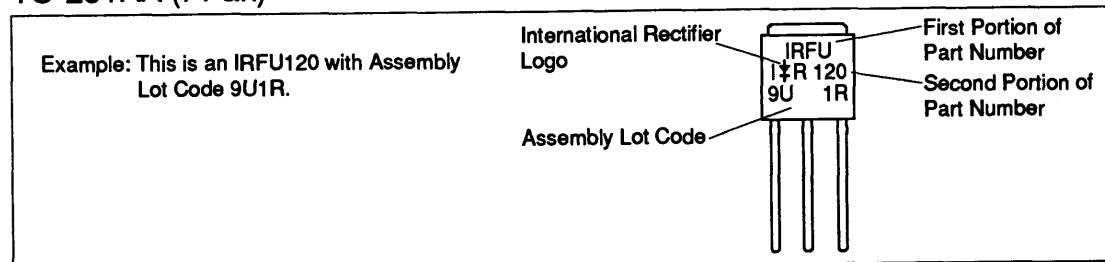
## TO-252AA (D-Pak)



## HD-1 (HEXDIP)



## TO-251AA (I-Pak)



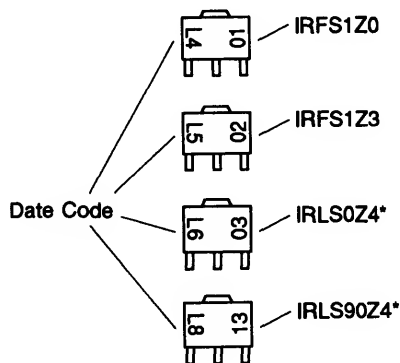
## SOT-89

The two letters on the right hand side of the device specify the part number.

The two numbers on the left hand side of the device specify the date code.

Both sets of characters facing outward indicate that the SOT-89 is a HEXFET.

\* Product not yet available at the publishing date of this document.



## Appendix E


### Other Catalogs

<b>Order No.</b>	<b>Description</b>
GSP-1	Government and Space Products – Power Semiconductors Designer's Manual
HDM-1, Vol. 1	Application Notes and Reliability Data – HEXFET Designer's Manual
HDM-1, Vol. 2	DIPs, D-Paks, I-Paks, Logic Level Devices – HEXFET Designer's Manual
HDM-1, Vol. 3	TO-220, TO-247, FullPaks, Current-Sensing Devices – HEXFET Designer's Manual
HDM-1, Vol. 4	Power Modules – HEXFET Designer's Manual
IGBT-2	Insulated Gate Bipolar Transistors (IGBTs) Designer's Manual
MGD-I	MOS Gate Drivers – Power Integrated Circuits Designer's Manual
MPIC-4	Microelectronic Relays Designer's Manual
PIP-90	Power Interface Products Designer's Manual
PMD-I	Power Modules Designer's Manual (Medium and High Power Rectifiers/Thyristors)
SDM-1	Schottky Rectifiers Designer's Manual
NRPM-2	Rectifiers, Standard Recovery Type
SHVR-1	Rectifiers, Standard Recovery Type – High Power
FRPM-1	Rectifiers, Fast Recovery Type
NTPM-2	Thyristors, Phase Control Type
IPM-1	Thyristors, Inverter Type
SFC	Short Form Catalog – Power Semiconductors Product Digest

# Other Surface Mount Devices



## Power Integrated Circuits

**International**  
**IOR Rectifier**

Part Number	V <sub>S</sub> Offset Supply Voltage (V)	V <sub>BS</sub> , V <sub>CC</sub> Output Voltage (V)	I <sub>OUT</sub> Sink/Source (A)	P <sub>D</sub> Max Power Dissipation (Watts)	Description	Case Style
IR2110E	10 - 500	10 - 20	2	10	High Voltage Gate Driver	<b>LCC</b> 16 PIN DIP 8 PIN DIP 8 PIN DIP 20 PIN DIP 
IR2110S	10 - 500	10 - 20	2	1.25	High Voltage Gate Driver	
IR2125S	10 - 500	10 - 20	1A/2A	—	Current Limiting High Side MGD	
IR2121S	10 - 20	10 - 20	1A/2A	—	Current Limiting Low Side MGD	
IR8400S	6 - 28	—	1 A per chan	—	Quad High Side Switch	
					MGD = MOS GATE DRIVER	



## Schottky Rectifiers

0.7 - 6.6 Amps

Part Number	VRRM (V)	I <sub>F</sub> (AV) @ T <sub>C</sub>		V <sub>FM</sub> @ I <sub>FM</sub> T <sub>J</sub> = 25°C (V)	I <sub>FSM</sub>		I <sub>RM</sub> @ T <sub>J</sub> = 125°C & Rated VRRM (mA)	Max. T <sub>J</sub> (°C)	Case Style
		(A)	(°C)		50 Hz (A)	60 Hz (A)			
10MQ040	40	1.1	90	0.55	30	32	50	125	<b>D-64</b> 
10MQ060	60	0.77	110	0.62	10	11	7.5		
10MQ090	90	0.77	110	0.81	10	11	5.0		
15MQ040	40	1.7		0.55	60	64	50	125	<b>T0-252</b> <b>D-PAK</b> 
30WQ03F	30	3.3	109	0.63	40	42	8.5	125	
30WQ04F	40	3.3	109	0.63			12.0		
30WQ05F	50	3.3	108	0.71			12.2		
30WQ06F	60	3.3	108	0.71			16.0		
30WQ09F	90	3.3	107	0.92			1.75		
30WQ10F	100	3.3	107	0.92			2.00		
50WQ03F	30	5.5	97	0.67	45	47	14.1	125	
50WQ04F	40	5.5	97	0.67			20.0		
50WQ05F	50	5.5	95	0.72			24.0		
50WQ06F	60	5.5	95	0.72			30.0		
50WQ09F	90	5.5	95	0.95			2.6		
50WQ10F	100	5.5	95	0.95			3.0		
6CWQ03F	30	6.6	101	0.55	45	47	14.1	125	
6CWQ04F	40	6.6	101	0.55			20.0		
6CWQ05F	50	6.6	98	0.58			24.0		
6CWQ06F	60	6.6	98	0.58			30.0		
6CWQ09F	90	6.6	98	0.85			2.6		
6CWQ10F	100	6.6	98	0.85			3.0		

## Ultra-Fast Recovery Rectifiers


1 to 6.6 Amps

Part Number	VRRM (V)	I <sub>F</sub> (AV) @ T <sub>C</sub>		V <sub>FM</sub> @ T <sub>J</sub> = 25°C I <sub>F</sub> (AV) (V)	I <sub>FSM</sub>		P <sub>thJC</sub> DC (°C/W)	Max. t <sub>rr</sub> (ns)	Case Style
		(A)	(°C)		50 Hz (A)	60 Hz (A)			
10MF2	200	1	122	0.98	25	28	160	50	<b>D-64</b> 
30WF10F	100	3.3	104	1.35	30	31.4	8	30	<b>T0-252</b> <b>D-PAK</b> 
30WF20F	200	3.3	104	1.35	30	31.4	8	30	
30WF30F	300	3.3	104	1.35	30	31.4	8	30	
30WF40F	400	3.3	104	1.35	30	31.4	8	30	
50WF10F	100	5.5	104	1.1	45	47	6	40	
50WF20F	200	5.5	104	1.1	45	47	6	40	
50WF30F	300	5.5	104	1.1	45	47	6	40	
50WF40F	400	5.5	104	1.1	45	47	6	40	
6CWF10F	100	6.6	117	0.98	45	47	5	30	
6CWF20F	200	6.6	117	0.98	45	47	5	30	




## Power MOSFETS High Reliability


### IRFE Series — N-Channel

Part Number	V <sub>DS</sub> Drain Source Voltage (Volts)	R <sub>DS(on)</sub> On-State Resistance (Ohms)	I <sub>D</sub> Continuous Drain Current 25°C Case (Amps)	I <sub>DM</sub> Pulse Drain Current (Amps)	P <sub>D</sub> Max Power Dissipation (Watts)	Case Style
IRFE024	60	0.17	8.0	32	20	LCC 
IRFE110	100	0.6	3.5	14	15	
IRFE120	100	0.30	6.0	24	20	
IRFE130	100	0.18	8.0	32	25	
IRFE210	200	1.5	2.25	9	15	
IRFE220	200	0.80	3.5	14	20	
IRFE230	200	0.4	5.5	22	25	
IRFE310	400	3.6	1.25	5.5	15	
IRFE320	400	1.8	2.0	8	20	
IRFE330	400	1.0	3.0	12	25	
IRFE420	500	3.0	1.5	6	20	
IRFE430	500	1.3	2.5	10	25	


### IRFN Series — N-Channel

Part Number	V <sub>DS</sub> Drain Source Voltage (Volts)	R <sub>DS(on)</sub> On-State Resistance (Ohms)	I <sub>D</sub> Continuous Drain Current 25°C Case (Amps)	I <sub>DM</sub> Pulse Drain Current (Amps)	P <sub>D</sub> Max Power Dissipation (Watts)	Case Style
IRFN044	60	0.40	34	136	75	SMD-1 
IRFN054	60	0.27	45	180	100	
IRFN140	100	0.100	22	88	75	
IRFN150	100	0.073	27	108	100	
IRFN240	200	0.18	14	56	75	
IRFN250	200	0.100	22	88	100	
IRFN340	400	0.55	8.0	32	75	
IRFN350	400	0.315	11	44	100	
IRFN440	500	0.89	6.0	24	75	
IRFN450	500	0.415	10.4	41	100	
IRFNG40	1000	3.5	3.0	12	75	
IRFNG50	1000	2.0	4.5	18	100	

### IRFE Series — P-Channel


Part Number	V <sub>DS</sub> Drain Source Voltage (Volts)	R <sub>DS(on)</sub> On-State Resistance (Ohms)	I <sub>D</sub> Continuous Drain Current 25°C Case (Amps)	I <sub>DM</sub> Pulse Drain Current (Amps)	P <sub>D</sub> Max Power Dissipation (Watts)	Case Style
IRFE9024	-60	0.28	-6.0	-24	20	LCC 
IRFE9110	-100	1.2	-2.6	-10	15	
IRFE9120	-100	0.6	-4.0	-16	20	
IRFE9130	-100	0.3	-6.5	-25	25	
IRFE9210	-200	3.0	-1.6	-6.5	15	
IRFE9220	-200	1.5	-2.5	-10	20	
IRFE9230	-200	0.8	-4.0	-16	25	

### IRFN Series P-Channel

Part Number	V <sub>DS</sub> Drain Source Voltage (Volts)	R <sub>DS(on)</sub> On-State Resistance (Ohms)	I <sub>D</sub> Continuous Drain Current 25°C Case (Amps)	I <sub>DM</sub> Pulse Drain Current (Amps)	P <sub>D</sub> Max Power Dissipation (Watts)	Case Style
IRFN9140	-100	0.20	-17	-68	75	SMD-1 
IRFN9240	-200	0.51	-8	-32	75	

## Radiation Hard HEXFETS

### N-Channel

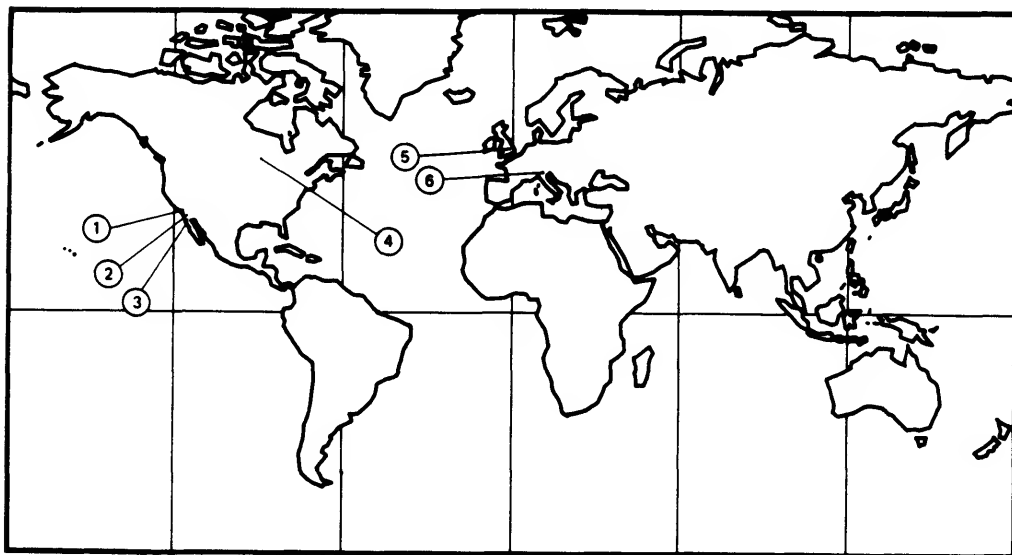
Part Number	V <sub>DS</sub> Drain Source Voltage (Volts)	R <sub>DS(on)</sub> On-State Resistance (Ohms)	I <sub>D</sub> Continuous Drain Current 25°C Case (Amps)	I <sub>DM</sub> Pulse Drain Current (Amps)	P <sub>D</sub> Max Power Dissipation (Watts)	Case Outline Number (2)	Notes	Case Style
IRHE7110	100	0.6	6	20	20	H22		LCC 
IRHE8110	100	0.6	6	20				
IRHE7130	100	0.18	8	25				
IRHE8130	100	0.18	8	25				

**International  
IOR Rectifier**

159

# International Rectifier

...around-the-world manufacturing  
to serve worldwide needs.



- |  |  |
|--|--|
| <p>① <b>El Segundo, California</b></p> <ul style="list-style-type: none"><li>• Power MOSFETs, custom hybrids, rectifiers, thyristors, government/military/hi-rel devices, microelectronic relays</li></ul> <p>② <b>HEXFET America</b><br/><b>Rancho California, California</b></p> <ul style="list-style-type: none"><li>• Dedicated to power MOSFETs</li></ul> <p>③ <b>Tijuana, Mexico</b></p> <ul style="list-style-type: none"><li>• Schottkys, thyristors, high power rectifiers</li></ul> | <p>④ <b>Ontario, Canada</b></p> <ul style="list-style-type: none"><li>• High voltage columns, open assemblies, heat sinks</li></ul> <p>⑤ <b>Oxtd, England</b></p> <ul style="list-style-type: none"><li>• Power MOSFETs, power modules, alloyed rectifiers</li></ul> <p>⑥ <b>Turin, Italy</b></p> <ul style="list-style-type: none"><li>• Rectifiers, thyristors, diode bridges, power modules</li></ul> |
|--|--|

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